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THE

EXISTENCE OF THE DEITY

EVIDENCED BY

POWER AND UNITY IN CREATION;

FROM THE RESULTS OF

MODERN SCIENCE.

BY

THOMAS WOODS, M.D.

MALO MORI QUAM FOEDARI
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AND

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BY THE AUTHOR.

PREFACE.

A few years ago, I was occupied in endeavouring to find the immediate cause of the heat of chemical combination; and theory led me to ascribe it to the loss of volume between the combining substances, such as oxygen and carbon, when they approach each other to unite, after having come within an insensible distance of each other; just in the same way as the particles of a simple body come together, losing volume when the body cools. If, however, this were true, the carbon and oxygen should, when leaving each other in decomposition, absorb volume from other substances, and produce a corresponding amount of cold. But as I had never heard of the latter proposition having been entertained, I was inclined to abandon the idea. I examined it, however, by experiment, and I found the theory was perfectly correct. Encouraged by this success, I continued both to theorize and experiment, and I published some papers in the "Philosophical Magazine," and "Proceedings of the Royal Society." On thinking over these subjects, or rather, these portions of the same subject, as a whole, I could not help being struck with an evidence they afforded of the Existence and Power of the Deity. I need hardly say I desired that the same conviction might be supplied to others, and I determined to publish briefly the train of thought suggested to me. I mention these particulars, firstly, as a reason for offering to the public a book on a subject so frequently and so well treated, although I present it in a new point of view; and secondly, to explain why I have referred so often to my own papers. This little volume entirely springs from them, and this fact must be my excuse. I have, also, to save trouble to my readers, given, in an Appendix, the principal of those to which I have referred.

My only desire is, that this Essay may be found useful, and that the facts and reasonings may carry the same conviction to others that they did to myself; and I will not regret that I cast my bread upon the waters, if I shall know that it has accomplished any good, even after many days.

THOMAS WOODS, M.D.

Parsonstown.

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THE
EXISTENCE OF THE DEITY.

CHAPTER I.

It is a melancholy thought that in the middle of the nineteenth century, it should be considered necessary to offer evidence of the existence of the Deity; not alone of his attributes and his revealed relations to us, but really of his very existence. It appears amazing to the convinced mind that the thousand miracles we every day behold; for almost all occurrences are miracles by which we are not astonished, only because we are familiar with them; it appears amazing, I say, that these wonders do not show to every intelligent observer the hand and mind of some Superior Being. But the natural corruption of the human heart, or the power of the devil, or perhaps the combination of both, is such that men seem blinded in a way that appears extraordinary when their general character for acuteness in other matters is considered.

In the following pages, I have endeavoured to bring forward an argument for the existence of the Deity founded, not on the mechanical appliances of matter, but on the impossibility of its present condition being such as it is, without the interference of some power at present unknown to it. I endeavour to show that the material from which the *forms* of matter are made must have been previously elaborated, and that ONE hand must have fashioned all things, as the same plan runs throughout different departments of creation which have no connection with each other, except the scheme on which they have evidently been worked out.

If a person showed to another a house made of bricks as a proof that some designer or builder had been busy, it might be objected that the bricks came together into the shape of the house by some convulsion of the earth or its elements, or perhaps by some other unseen means which chanced so to drive them into their present state; "For," says the objector, "take a box of bricks and let it be shaken, and they most likely will be afterwards found lying in regular layers, or it may be with some defined figure; if then the human effort brings these bricks so together without design or intention, might not some other action long continued and somewhat different have formed them into a house." This is the kind of argument generally used by infidels to antagonize the evidence of design.

Now, I endeavour to prove the existence of the Deity, not, so to speak, from the fact of the house being present and the unaccountability of its being there without a builder, but from the very nature of the brick itself and the necessity for its having been made before it was used as a building material.

If also a human being were given power to visit different planets, that he might decide the vexed question of the plurality of worlds, and that in all he found houses such as are built on this earth, would he not at once affirm, even although he might have seen no inhabitants, that not only the planets were peopled, but that the same kind of persons would be found in each. This imaginary journey will illustrate my line of argument. I visit the different portions of creation, the inorganic and organic world, and, as far as is revealed, the mysteries of the world to come, and I find indications of the same mechanism in each, and I therefore conclude that the same intelligence has made them all.

This general view, I trust, will aid the reader to understand more perfectly what follows, and I greatly hope if he has sufficient patience to read through this essay which, it must be confessed from the nature of its material, cannot be made very attractive in its style, he will not have spent his time in vain.

Matter—the material of our physical world—presents itself to us under two different aspects; one as a mass without any particular shape or external configuration, such as unwrought clay or stone, and another in which structure or arrangement for some purpose is evident, such as we find in crystals or the various parts of the Animal body. Theologists have generally directed attention to the latter as a proof of the existence of a Deity, judging it difficult for reason to withstand the arguments to be derived, not only from the admirable mechanism of such organs as the eye or hand, but also from the consideration that admirable as the mechanism is, it sinks into insignificance, as a proof of a designing mind, when compared with the adaptation of parts to the circumstances in which they are placed. From the other aspect of matter theologists have turned away, not thinking that any proof of the Deity can be drawn from a shapeless mass. Chalmers distinctly repudiates the idea, he says,* "It is not brute matter in lumpish and unshapen masses that indicates a Deity.". But from theologists on this point I entirely differ.

It is a most remarkable instance of the power of the enemy of all truth to deceive, that this idea of

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* Chalmers, Natural Theology, vol. 1, p. 158.

Chalmers should have been tacitly countenanced by other writers on the same subject, and that a steady adherence to the consideration of secondary forms or mechanical structure of matter, should always have been offered as proofs of an all-powerful providence; because we find that, whenever any arrangement or disposition of parts, however beautiful, or wonderful, or evidently designed it may be, is instanced, the answer of the sceptic is always ready, "the *laws* of Matter alone produced it;" and he adduces as proof of his assertion the very "unshapen mass," for he tells us that by the inherent laws of matter, the particles came together attracted by their own power; and further he shows us how saline matter from its solution in water can form crystals, which under certain circumstances, run into the shape of organic bodies; and from these facts he argues, that if these forms can be assumed by matter in a short period of time, it might not require other powers to produced, say, an eye, or an ear, which are only more complicated results, provided time and circumstances be given. Nay, he even goes further, and declares a *necessity* exists for the present constitution of the universe, because the laws to which matter is subject could not allow of any other disposition, and that even if any other did obtain, these laws would bring it to its present state again.

I believe it is generally granted to these infidel reasoners that matter is really subject to laws; that is, that it, as matter, has connected with it, as part of its constitution, some influences which it must obey. If so, all these mechanical contrivances so sedulously brought forward as proofs of a designer, lose partly their weight, if these laws cannot be traced to a law-giver. In fact, if such an assumption be admitted, it remains to be proved whether the powers we see in matter are its essential qualities, resident always in it, and inseparable from it, and independent of other source except itself; or whether they are impressed upon it by a great first cause.

I do not believe that matter, simply as matter, is necessarily connected with any inherent law whatever, or that it can exert any influence in the origination of motion, form or force, and the consideration of the truth of these propositions which I hope to prove by arguments derived from the constitution of the "unshapen mass," taken in connection with the results we see produced in creation, offer to my mind more conviction of the being and power of the Deity, than all the arguments which can be adduced from all the secondary formations or adaptions in existence, wonderful, and almost irresistible, though they be.

In this part of my essay, therefore, I will endeavour to prove that what are called "the laws of matter" have nothing to do with matter itself as to their origin; but that they result altogether from its molecular constitution, or from the arrangement and disposition of its parts; that the particles of matter could not have come together so as to form a mass, except some power different from any at present recognized had joined them; consequently that certain arrangements must have been made with the particles before any law could have come into operation, or any power into effect; and I can then deduce as a corrollary that it is altogether ***impossible*** the physical world could exist independently of a deity; and that as his arrangements constitute whatever power matter possesses, to Him must all power belong.

For the purpose then of finding the extent of power possessed by matter independently of the arrangement to which it is subject, I will briefly examine the phenomena said to be produced by its inherent laws; and as *attraction of gravitation* is generally supposed to show very clearly the action of matter on matter, and to be a proof of the existence of power possessed by matter itself, I will first address myself to it.

At first sight, no doubt, the approach of masses to each other without apparent cause suggests this idea of innate force; but, on consideration, we have no proof that in this case the matter of one mass acts on that of another. To prove it, we should see one *particle* affecting a second; that is one atom without the arrangement or disposition which characterizes the *mass*. When one mass attracts another, this arrangement or condition of particles is present in each, and may, for all we know, influence the movement. It cannot be proved that matter solely will affect other matter, for it cannot be procured without its accompanying disposition of particles or molecular constitution; and it is questionable whether this disposition or arrangement may not produce the action altogether. It is known that if a body in motion be suddenly stopped by coming into contact with some immoveable body, the motion is converted into heat; or, if a disc of iron in rapid rotation be delayed by the attraction of a magnet, it becomes raised in temperature also;* motion here being likewise converted into heat. It is known, too, that heat can reciprocally be converted into motion.† If, therefore, there are examples of molecular disturbances capable of giving rise to motion among masses, we cannot positively affirm that attraction of gravitation does not proceed from particular arrangement of particles, influenced or altered in such a manner by the co-existence of two bodies, that motion in the direction of each may be generated. Indeed, when we consider that a disturbance of the state of the particles on the surface of two bodies, causes them to move towards, or away from each other, either to attract or repel, as when masses are excited by frictional electricity, it cannot be denied that an attraction or repulsion may depend on ***molecular condition,*** and that it may not spring from any power resident in the molecules themselves.

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* Foucault. † Grove.

Grove has proved the correlation of physical forces; that is, that one force, such as heat, may be changed into another, such as electricity; every force appearing either as that force itself, or in some shape equivalent to its former state. The force cannot disappear, or rather, be lost; and this indestructibility is called the conservation of force, and is an admitted principle.

Faraday says, that if attraction of gravitation is a force exerted between masses of matter, and varying inversely as the square of the distance, the above law cannot be maintained, in fact, that it would be "in direct opposition to it;"* and Sir I. Newton says in his third letter to Bentley, "That gravity should be innate, inherent, and essential to matter, so that one body may act on another at a distance, through a ***vacuum,*** without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking, can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws, but whether this agent be material or immaterial, I have left to the consideration of my readers."

* Phil. Mag. vol. XIII, p. 228.

Taking into account, therefore, that no direct proof can be given of the attraction of matter on matter without the accompanying circumstance of some arrangement or grouping of the particles; and also, that other facts show it is not impossible, when this aggregation of particles exists, that one force may be the equivalent and be changed into another, so tending to the probability that attraction may be the result of molecular condition; taking into account, likewise, the opinion of such men as Faraday and Sir I. Newton, it is, to say the least, not proved that attraction of gravitation shows any inherent power in matter, or that it is the result of any innate law.

Of course, I do not endeavour to account for the phenomenon we are speaking of; I only wish to show it is possible that attraction of gravitation may be produced by certain arrangements in the molecular state, or that if there is no direct proof that attraction is the consequence of disturbance of the disposition of the particles of matter, or that it is due to arrangement or molecular structure, yet that there is no proof to the contrary, much less that it is independent of it.

Indeed, it is no unfair supposition to imagine that without a reciprocal action of two masses, each on the other, no such force as attraction could exist. Of course, attraction could not be exercised without a second body, or a thing to be attracted; but it also remains to be proved whether such a force exists, or could exist, if only *one* body were to be found: in other words, whether attraction is not a double force acting equally in opposite directions, consequently requiring two masses for its development, and therefore not emanating from matter at all, but from its arrangements.

But in the mass itself do not the particles attract each other so as to preserve the solidity and cohesion of the parts? How could matter remain in mass if the particles do not attract each other, and with great force? And must not this attraction of cohesion be a power emanating from the particles themselves? I will return to the consideration of these questions when I have spoken of the other forces of matter.

And with respect to these other forces, it can be still more clearly demonstrated that they are connected, not with matter itself, but with the changes the molecular structure undergoes when they are produced; for instance, let us consider *Heat.*

In order to develope heat, there must be, as in the case of attraction, *two* distinct masses, each capable of expansion; the phenomena constituting this force being expansion in one body, and contraction in another, both going on at the same time; this force, like all others connected with matter, being a double one acting equally in opposite directions. As the result of attraction consists in the equal motion of two *masses* in opposite directions; so the evidence of heat is the motion of *particles* after a similar manner. If the two masses of matter acting on each other in attraction are unequal, the larger offers a greater resistance to motion, and hence moves to a less distance. So with heat; when resistance to expansion is present, the amount is proportionably lessened, but *temperature* is produced to a corresponding degree. In fact, the phenomenon of heat, looked at in the simplest point of view, may be said to consist of an increase and diminution of volume, each in a separate body. This increase may show itself altogether as volume, or as temperature where resistance to expansion is present. For instance, if a piece of metal heated to 500° F. be placed in contact with a similar piece at 100° F., the result is, that the more highly heated metal loses 200° F., while the other gains 200° F., and a mean temperature of 300° F. is produced in both. But if the heated metal be placed in water at 100° F. the temperature of the latter never rises above 212° F., because, on account of the expansion into steam, the heat the metal loses is developed partly as volume and partly as temperature. If the metal were placed in contact with some body capable of undergoing expansion without any resistance, the whole heat would be developed as volume, and none as temperature. Heat, then, as a physical manifestation, may be looked on as increased volume. When this increased volume is prevented from developing itself, it shows as temperature, or compressed volume, and the extent to which this volume does appear, is called expansion. When heat appears in one body it always disappears from another, and the contrary. No expansion or contraction can take place except the opposite is at the same time going on in some other mass. Let pressure, for instance, be made on any substance, æriform or otherwise, whereby the particles are approximated, the consequence is, that some other body becomes expanded or heated; and let any substance be expanded, and cold or contraction is produced in others. There is no exception to this proposition, that particles cannot move in one direction only.

When we consider, then, that heat is always imparted from one body to another, or is the equivalent of some other force, and may always be looked on as an altered relation of matter to its volume in two masses in equal and opposite directions, it will be apparent that it is a power not inherent in, or springing from matter itself, but dependent on the disposition or arrangement made amongst the particles, and the fixity of amount of volume they require.

But, looking on temperature as compressed expansion, or tension, or potential volume, this expansion or contraction of a heated or cooled body being always accompanied by an equal and opposite state in other bodies, demonstrates that a certain relation exists not only between the matter and volume of a single mass, but between those of every mass in the universe. The quantity of volume, (volume being regarded from the point of view I have indicated) as connected with matter being constant, no change either as to increase or loss *on the whole* can take place; therefore it is that no movement amongst particles is possible, except an equal and opposite one simultaneously occur; and this brings me to the question I promised to consider. Do the *particles* in the mass attract each other? and if not, how can cohesion exist?

There is certainly no appearance of attraction, or rather alteration of condition caused by it. The reason cohesion exists, is not, as far as we can judge, from attraction of particles but from *the absence of the opposite movement that must accompany their separation;* for, let a body be brought near to another whose temperature differs from it, and an exchange immediately takes place, expansion or contraction results, a change which the attraction of the particles never could have accomplished. Change amongst the particles of a mass is the consequence of another mass with an increased or lessened volume being present; consequently it cannot be said that any force emanating from, or inherent in themselves affects them; but that any change produced, such as these phenomena of heat, must be ascribed to the arrangement of the particles, and to the fact that a certain relation exists, and must continue between volume and matter. Cohesion of particles in the mass is the natural result of the dependence of molecular motion on the presence of another body capable of giving or taking up volume—without which no movement can take place; the particles remain fixed if no opposite movement of other particles occur, and the well-known phenomena of heat and other forces, resulting from the molecular constitution of matter, show that no such power as attraction ever appears to interfere with the interchanges of relation or condition between two masses concerned in their production.

This indestructibility of volume, and necessity of a second body in a state fitted to undergo the opposite change before any movement can take place in any substance, not only supplies a reason why cohesion may exist independently of attraction, but it also offers a key to some difficulties connected with other physical phenomena. For instance, why is it that two masses of water separated mechanically to as small a distance as is possible, form two distinct and separate bodies, and act in their relations to other matter as such; and yet if water be expanded into steam, the distance between its particles must be much greater, but they act together as one body. In the case of the two masses, however closely they may be brought together, they are still said to be at a *sensible* distance, while the particles in a state of steam, at a low temperature, may be 20,000 times as far asunder as they were when forming water, yet they are as much one body as the water itself is, and are said to be at an *in*sensible distance. The reason why the particles of steam still form one body is, that the volume connected with them has been taken from other matter, and cannot leave them until it finds a suitable substance to become attached to. The particles therefore continue as much bound together, however expanded, as any other body; but the two masses of water, however closely approximated, have no volume in common, and therefore there is no link between them.

And now, if we consider electricity and its several forms, galvanism, &c., with respect to the same idea of matter being endowed with certain powers, we find that to produce them, the *arrangement* of particles alone is changed, and that *one* mass of matter could not be so circumstanced as to originate this force. Just as with heat and attraction, *two* masses are required to develope it; and as much electricity as it produced in one is drawn from the other, and exactly opposite states are simultaneously generated, so that no change in *one* direction only occurs.

Sufficient has now been said, I think, to show that matter itself possesses no inherent power; not being able in any instance either to originate or continue any change; and that all the forces and the changes producing them are entirely the result of certain arrangements made in its molecular condition.

CHAPTER II.

In the preceding chapter, I endeavoured to show the dependence of the developement of power or force on the general arrangements of matter; proving by the circumstances required to call them forth, that they are not exercised by matter itself in virtue of any inherent principle or law to which it is necessarily subject—nor by volume, although in the latter only is change produced, but by the relation which has been impressed on both, and the arrangements of the particles which matter could not of itself have made. I will now consider whether these general arrangements are characterized by any circumstances, which prevent the supposition of the possibility of their present condition having occurred by chance.

When one element combines with another intimately, or forms what is called a chemical union, a certain fixed quantity only is engaged in the action; thus fifty grains of the metal, tin, will unite with sixteen grains of sulphur or eight grains of oxygen. It will not and cannot unite with more or less of either, except twice the same quantity, or some multiple of it; it cannot, for instance, unite with any number of grains of sulphur between sixteen and thirty-two, or with oxygen between eight and sixteen. Oxygen will combine also with all other bodies in the same quantity as with tin. When we know the amount in which one body unites with another, we can tell that it combines in exactly the same with all others. The *quantity* of matter therefore concerned in molecular changes is definite and fixed.

The *volume* of this fixed quantity is also definite and limited. If this quantity, or, as it is called, the chemical equivalent, be turned into vapour, it will be found of the same bulk in all substances at the same temperature, or some multiple of a certain bulk. Thus, one grain of hydrogen, the chemical equivalent, is exactly equal in bulk to the chemical equivalent of chlorine, nitrogen, and other substances, while it is twice as large as that of oxygen. The same relation exists between gases and vapours. Thus steam and hydrogen have the same sized equivalent, and arsenic and phosphorus are similar to oxygen. In fine, the chemical equivalents of all substances have either exactly the same volume, or size, in a state of vapour at the same temperature, or are some multiple of each other. Thus the *volume* of the quantity connected with the molecular condition is definite and fixed as well as the quantity itself; and as it is by the union of these definite quantities of different bodies the forces such as heat, galvanism, &c., are produced, these forces are themselves definite and fixed also. Thus eight grains of oxygen uniting with potassium generate a certain quantity of heat and electricity, and never either more or less. When the eight grains of oxygen unite with other bodies, the quantity of heat produced is either the same or some multiple of it; this specific amount being liberated for every combination with every substance.* And not only is the *form* of matter,—for every substance has its own particular shape as shown in crystallization—definite and settled, the *quantity* which is affected in its changes specific and fixed, and the *forces* which are evolved invariable in amount, but the very *time* in which every change and action takes place is equally subject to like conditions.

These changes which matter undergoes in respect to volume or combination of different kinds do not occur either suddenly or after an unsettled manner; whether we heat a body, or cause that body to unite with another, or again cool or separate the combined elements, a fixed and invariable, or specific period of time must be accomplished during each process. For instance, under similar circumstances mercury requires much less time to become heated to a certain extent than water. Ether expands into vapour much more rapidly than alcohol, zinc combines more quickly with oxygen than copper does; and the reverse movements, such as cooling, liquefaction of vapours and decomposition equally differ in the amount of time the change requires, and are equally invariable and specific in the period they absorb. The manifestations of the other forces, such as electricity, &c., produced by the molecular changes of matter, are also limited by *time.** For the production of galvanism, decomposition at one end of a metal pair is necessary, and the more quickly this is accomplished, the more rapidly will the electricity be disengaged; but the decomposition requires a certain amount of *time,* and hence the quantity as well as the intensity of galvanism is limited by the period the fluid of the cells require for their changes. On this consideration, I believe the true principle for theoretically finding the different amounts of galvanism from various pairs rests, and I have endeavoured to present it in this point of view.*

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* I experimentally proved this proposition; the results have been published in the proceedings of the Royal Society, *see* Appendix B. I also proved in 1851, that the heat absorbed, when a compound is decomposed, is exactly equal to that given out when the compound is formed, *see* Appendix A.

Whenever decomposition occurs, the same quantity of heat that was generated by the combination of the elements is again absorbed, and as this absorption requires greater or less time according to its amount, it follows that those compounds which generate but little heat in their formation require but little time to decompose. Hence arise what are called explosive substances, such as oxide of silver, or hypochlorous acid; some of these actually produce cold by the combination of the elements and are very unstable, being most easily broken up into more persistent compounds.

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* See Appendix C.

But these circumstances of matter, such as definite form, quantity, volume and time are not only related among separate bodies, but in the same substance it is found that one peculiarity will depend on, or be influenced, apparently, by another. For instance, the atomic weight, or the quantity that enters into chemical combination, is shown by Dulong and Petit to be inversely as the specific heat; or, in other words, the smaller the combining proportion, the more capacity or room, as it were, any substance has for heat; consequently, the more is rendered latent by the body receiving a given supply. I have shown that when liquids expand into vapour, the same law holds good, that is, the smaller the combining proportion, the greater is the expansion, and the more heat is rendered latent.* Other relations between the characteristics of bodies are likewise pointed out by philosophers, such as the melting and boiling points depending somewhat on composition; all, however, agreeing in this, that just as different substances are connected with each other by similarity of properties, so are these several properties connected amongst themselves by some indissoluble chain.

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* Philosophical Magazine, January 1852.

So strongly marked is this dependence of circumstances on each other, and so plain the connection, that philosophers, in all ages, have endeavoured to bring all the changes and phenomena occurring in matter, both statical and dynamical, to some *one* law or common regulator of the whole, seeking to trace to a general formula all the facts and truths of science. But their labour has been hitherto in vain. Enough is known to declare that all creation has sprung from one mind, and is arranged on one plan, but it cannot be shown that any one law of necessity connects all the relations or occurring events; on the contrary, it is frequently seen that modifications of, and departures from the most established rule will take place to suit an occasional circumstance, or to carry out a desired end. Some unknown condition of a well-known body without any appreciable change in its constitution will produce effects strongly at variance with the general behaviour of the body itself, as in the instance of ozonized oxygen; and resistance to certain changes will sometimes characterize substances which, under usual circumstances, are violently affected, as in the case of passive iron in nitric acid. Compound substances, also, of quite *different behaviour,* and which have characters of the most opposite kind, are sometimes made up of exactly the same elements in the same proportions. Thus olefiant gas and paraffine are precisely similar in composition in every way, and yet the former is a gas and readily unites with many other bodies, whilst the latter is a solid and so averse to combination, that its name is derived from the fact of its weak power of affinity. Nay, in the very same substances, under slightly different circumstances, we find exactly opposite traits. Thus, sulphur and arsenic spontaneously change the shape of their crystals after fusion. Bisulphuret of iron also appears under two different forms, and it acts in each as a body having different proportions. Examples of this departure from what might be termed *law,* for particular purposes, might be greatly multiplied, and they become more numerous as knowledge increases; they certainly show that no actual *necessity* exists for the present arrangement of matter, and that no absurdity is involved in the idea of another; and at the same time that they do not weaken the belief that all created works flowed from the same origin, they declare that the details are still in the hand of the Master who produced them. Design in the molecular formation of matter is thus abundantly evident, for it is clearly framed in reference to the circumstances in which it is placed; and chance entirely excluded, not only by the sharp boundaries which define the properties which fit so harmoniously together, but by the very relaxation of a principle when it is necessary to accomplish an end.

CHAPTER III.

Having briefly considered the molecular constitution of matter, and having seen that in no case can a proof be produced of any power being inherent in, or emanating from matter itself; and that what are called "the forces" exercised by its means, are wholly the result of the disposition or arrangement of its parts—let us examine, for the purpose of applying the subject, the theories which have been brought forward to account for the present state of the material world. It will bring our enquiry into a short compass, if we take as types of all these theories the two great and opposite ideas of the formation of the existing constitution, as given, on the one hand by the Atomists, and on the other by Laplace. The former imagine a chance collection of atoms floating throughout space so as to form masses, and the aggregation of these into larger bodies, which obeying [illegible] innate laws or necessary requirements of matter, [illegible] themselves in certain relation to each other; and thus that its inherent properties have worked out the order and economy of the universe. On the contrary the reasonings of Laplace, in which he is more generally followed than are the Atomists, led him to think that the solar system was once a vaporous mist composed of all the present bodies it contains, and that gradually this vapour condensed, ring after ring being cast off consolidating into smaller masses, and that their motions resulted from the attraction of the several parts and an original motion common to the whole mass. These two ideas may be taken as types of all the fancies which, from time to time, have amused man with the endeavour to account for the mechanical arrangement of the world. But when we consider the constitution of matter, as at present known, we cannot but conclude that both are equally erroneous. For instance, how can it be proved that atoms can come together by any force emanating from themselves, independently of the power given them by their arrangement in mass, until it is first proved that one indivisible atom is influenced by another singly and separately from others. This cannot be shown; and I have endeavoured to prove it is improbable. But granting even that this power of attraction is inherent in matter, and that atoms can affect each other, drawing together from a distance, yet they certainly could never form a mass; for we have seen that when particles arrive at the verge of an insensible distance from each other, about to form one body, they can no longer progress unless some other substance perform an equal and opposite movement, that is, unless to compensate the contraction, as which such an action may be regarded, some expansion to an equal extent takes place. If atoms, therefore, are supposed to have met, and to be capable of any amount of attraction on each other, still they could not come sufficiently near to make up a mass, unless some other mass was previously in existence; but as, according to the theory, there was none, so none by this force could be originated. It is therefore quite evident that some power different from any at present appertaining to matter should have been in the beginning, if atoms came together to form the masses that now appear.

The same objection, somewhat in the same direction, applies to the theory of Laplace. His idea of concentration could not be carried out, unless some other system were expanding to take up the opposite motion there going on. Matter, as at present known, cannot part with volume. I have shown that a certain volume is attached to it, and that this volume is as indestructible as the matter itself; in fact, that it is owing to this indestructibility we have all "the forces," one mass being obliged to take up the volume the other parts with, and that without this opposite movement, no disturbance could occur at all. Now if matter were always so constituted, how could the concentration spoken of by Laplace take place?

would not matter be parting with its volume? and would it not be necessary that some power, different from any at present known, should have been connected with it? Do we ever see now steam become water, or water become ice, without heat being produced? Do we see concentration in any way without a corresponding expansion in other bodies, or do we think it could so occur? The idea is at variance with all that experiment teaches, and, doubtlessly, not more so at one period of time than another. Indeed, the theory we are now discussing, seems to have taken its origin from a false notion of the structure of the nebulous masses seen scattered over the celestial vault. At one time, they were believed to be vaporous mists in process of condensation to form systems of stars; and, while their true nature was not known, they seemed to offer a proof of the *nebular hypothesis.* But these ideas have given place to others, as knowledge has been extended by superior means of research. Speaking of these nebulæ, M'Cosh says: "They were, at one time, supposed by certain speculators to consist of a sort of luminous matter, or star dust, out of which worlds are being made, even now, by general law. This supposition has not been confirmed by later investigation. Within these few years, not a few of these nebulæ which were regarded as being most certainly luminous vapours, have been shown to be stars. The magnificent telescope of Lord Rosse, not long after it began to be used, showed that the great nebula in Orion, which was supposed to be one of the most unresolvable of them all, consisted of clusters of distinct stellar bodies. Since that time, nebula after nebula has been resolved by Lord Rosse's telescope, and another of less power, but in a finer climate—at Cambridge in the United States. In 1850, Sir J. Herschel was prepared to declare it as being almost certain, since Lord Rosse's telescope had resolved, or rendered resolvable, multitudes of nebulæ, that all the rest could be resolved by a further increase of optical power; and the language might be made still stronger and more decisive, in consequence of what has been accomplished by that magnificent telescope since that date." M'Cosh and Dickie's Typical Forms, &c., page 406.

We may therefore, I think, reasonably conclude that the theory of the formation of masses by the condensation of vapour is also opposed to the present constitution of matter, and therefore untenable in its present condition. We must likewise attribute the existing state of the universe to some power different from any exercised by matter or any of its forces; and, inasmuch as all changes which generate the latter are brought about by the arrangements made in its parts, and their relation to each other, it is evident that whatever made these arrangements is the source of all the power they produce.

Thus the first step in the formation of a mass is seen to be impossible, if the so-called laws of matter are alone recognized; and the primary constitution and subsequent behaviour of substances in relation to each other would, by means of these, be no less unaccountable. For instance, if matter by any inherent power formed itself into masses, how can we explain the existence of the many different kinds and forms of it which are necessary for the production of the several phenomena of heat, light, and electricity, without which the universe as at present constituted could not continue. Why are some bodies solid, some fluid, and some æriform? Does not attraction equally exist between the particles of all? And if so, why, at the same temperature, should some remain with greater or less volume than others, these modifications being so exactly suited to the circumstances in which they are placed that none other could carry out the object they are designed to fulfil? If all things were solid they might lie inactive amongst themselves, without chemical action, except to a small extent, and therefore without change of temperature, or other changes necessary for the production of these results which chemical combination supplies. If all things were solid or æriform, it is also clear they would be equally unfitted for carrying out the phenomena of the physical world. Heat might be interchanged between substances of the same nature, such as solids or fluids, but there could be no modification of it. The change of solid into fluid, and fluid into vapour, not only are useful towards this modification, but also prevent its too great accumulation, or its too rapid dissipation. Without the presence of the different kinds of matter we could have no electricity, which is as necessary as heat; and without both different kinds and different forms we could not have that peculiar state of the latter force, galvanism, as useful and as little to be disregarded as either. Without æriform matter, we could not have light in sufficient abundance for many useful purposes; for although solid bodies may be made incandescent, yet they do not become sufficiently so for brilliant illumination. The electric light might be thought to be an exception, but this is in part produced by a fluid—that employed in the galvanic battery—or, if the effect of the magnet, this latter may be traced to the galvanic current too. The light of the sun is generally supposed to be produced by flame which surrounds it. Arago proved this, by finding that the direct light is not polarized, which is characteristic of that given out by flame, and not of that by solids; and I have shown the same supposition to be true by a photographic experiment.* The existence of all these various states of matter, looked at as a chance result of attraction of particles or any undesigned collection of atoms is quite unintelligible, but viewed as a preconceived and calculated operation, whereby the several parts of the universe are placed in the best possible position with respect to each other, as regards economy, order, and power, their design becomes more clear; and we are forced to believe that the power which I have endeavoured to show was acting on matter in the beginning, was not only different from any at present seen in it, but that it must be one no less Almighty than all prescient and all wise.

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* **Phil. Mag. July 1854. Appendix D.**

After thus considering these circumstances of matter, we are in a better position than before to analyse the arguments of those who would ascribe all its arrangements to its laws and requirements. One of these I alluded to in the commencement of the first chapter; that is, if a salt can crystallize from its solution, and assume different forms apparently unaided, except by its own powers, why cannot more complicated structures be produced if time and circumstances are allowed? Now let us enquire into all the arrangements made previously to the crystallization, and find whether the salt really crystallizes by its own powers, by any inherent necessity for it to take place, or whether it is possible it could crystallize without these arrangements having been attended to. In the first place it must be dissolved, a certain peculiar form of matter, fluidity, having been impressed on another substance before solution can take place; then this fluid must have been made capable of assuming a state of vapour, and of taking from other bodies the volume or heat necessary for that state; other bodies must also have been prepared to part with this required volume; and several other provisions also must have been arranged before crystallization could occur; so that in reality, a process such as this crystallization, or any other process, however simple it may appear, can be shown to depend not on any local changes, or on the isolated properties of one or two bodies, but that arrangements have to be brought into action, and numerous conditions have to be disturbed before any result could have been obtained; showing that the least and most uncomplicated of substances is not made a *unity* irrespective of other things, but that it forms a link in a chain without which that chain could not exist in its present form. And it likewise proves that whatever hand formed any part of the chain must have made it all; not by any chance disposition of parts, but evidently by so balancing and dove-tailing, as it were one principle on another, and by so hanging one action on the proper performance of the rest that the smallest movements, as well as the most complicated events, are carried out with the most perfect harmony. If it could be proved that this working out of any one result, much less of the universal system, depended on any power inherent in matter, necessity for such result might be argued, but I think it has been shown that the "forces" and changes occurring in the physical world are to be ascribed to the arrangements, and not to its innate powers, and therefore from the Arranger must all spring, and to the Arranger must all power belong.

The attempt to ascribe all physical phenomena to the inherent faculties of matter having appeared fruitless to some philosophers, they discard the idea altogether of any first cause, and they affirm that the present state of things is *eternal;* that the existing order has always been as it is, and will always continue in the same way. This eternity of matter with its changes and relations is thought to be proved by their unvarying amount, and the absence of anything new occurring under the sun. But the necessity of indestructibility to the present order of things precludes the possibility of destroying, as long as that present order is intended to remain. The system of the universe is based on the preservation of the relation between matter and volume, but there is no necessity for its remaining beyond the period alloted for their continuance. All the conditions connected with matter are *finite,* its *quantity,* as shown in chemical combination is fixed, its *volume,* as seen in the equivalents of vapours, is defined, the *forces* its changes produce are specific, the *time* of these changes is also limited and settled, and, in fine, there is nothing appertaining to matter that has not a beginning and an end, pointing to, if not proving the finite nature of matter itself. But happily we are not driven to conjecture or circumstantial evidence for the proof of a commencement. It is now well known from the researches of geologists, that there must have been a period in the earth's history prior to the existence of living beings; and if so, there must have been a beginning. And during the many ages this earth has passed through, several species of living beings have disappeared and others have replaced them. In this instance, also, we have a commencement and an end;* and thus, as far as proof can be given, we have it, that the things which are, have not been from all eternity; quite sufficient to show the limited duration of matter and its present conditions, although the intention for the preservation of the present economy prevents us now destroying either matter or its specific relation to its volume at our will.

Arguing, then, from the impossibility of the first step in the FORMATION OF A MASS being taken independently of some power different from any connected with matter, and seeing that this power must be Almighty, as being the source of all might, on account of being the author of the arrangements from which it springs; judging also from the perfect working and adjustments of the several parts of the world's machinery, that this power must be all-wise, how shall we denominate it? Does not the character correspond with that given of the Deity? and are we not driven from the reasoning I have used, even if there were no other proofs, to admit the existence of a God.

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* See "Truths of Revelation," &c., by the late Earl of Rosse, and McCausland's "Sermons in Stones."

So far I have endeavoured, from the "shapeless mass," to draw arguments for the proof of the existence of a Deity. I cannot help thinking that its molecular constitution, more than any figure it might possess, or any appearance of design it might be given, answers this purpose; but this reasoning from first principles may be extended further. If, for instance, the power that caused the arrangements in matter corresponds in character with what we are taught of the Deity, it ought to follow that not only in the constitution of the "shapeless mass" and its general management, but in all the other arrangements we witness, the impress of the same power must be seen. I will therefore investigate the other parts of creation to find whether the same mode of acting is carried on in each; and so far prove whether a similarity of operation in the different works ascribed to the Deity does not proclaim a common author for them all.

CHAPTER IV.

To introduce the reasoning on this part of our subject, which would trace in all the departments of creation a common authorship, as shewn by a unity of intention or correspondence in the mode, if not the means of acting, I would ask what is the extent of the power that is exercised by man independently of external assistance? From what does power spring? I have shown that it originates in the arrangements to which matter is subject. No substance can keep its volume, whether it be present as volume or temperature, if any other relatively less expanded or heated be present; and in this tendency to an equilibrium, or in this law of relatively equal volumes, is the source of nearly all the power we possess.

Let us take the effects produced by steam as a type of the results of the power employed by man, and examine the circumstances connected with their *development*. We find in the first place, that coal is burnt, that is, that carbon and oxygen are so brought together that they unite. The combination occasions a lessening of volume or temperature to the substances themselves—both taken as a whole; consequently, as no movement amongst molecules takes place in one body or in one direction only, some other substance must increase in bulk. Water, being placed in the vicinity of the combining bodies, takes up the volume or temperature they lose; it becomes steam, expansion to a great extent taking place, and a weight being correspondingly raised. This volume is then taken away by a colder or less relatively expanded body, and the weight descends. Now in this example, how is the power produced? Man does nothing but place together substances which on account of certain arrangements re-act on each other. Matter loses nothing, the same quantity is there at the end as at the commencement of the process; and although the volume or temperature on the whole is found to be less—for when power is produced by the transfer of heat from one place to another an equivalent of heat disappears—yet taking the work done as modified volume, as it can be again made to appear as heat, nothing has been lost or gained, and yet great power has been produced. The *arrangements* of the matter alone have been changed, although returning to their original condition, with the exception of the volume lost by the carbon and oxygen or combined substances, which is dispersed to other bodies but not destroyed. This volume has been the cause of the power immediately, but it could only act in virtue of the arrangements present in matter. If the law of relative volume did not exist, this volume could not, in the first place, be transferred from one body to another; and secondly, if the peculiar nature of the different substances did not require greater or less development of bulk to preserve the relation between their matter and space, this transfer could not cause expansion sufficient to be of much use. We must, therefore, look for the source of power only in the arrangements impressed on matter. As to *man* producing directly of himself any power, that is entirely out of the question; for in no instance do we find its generation referable to him. From the most complicated to the simplest machine for the production of effect, power originates in, and is kept up by the arrangements of matter which give rise to fixed and unalterable results, no power or effect being called forth except as a consequence or rather accompaniment of an opposite action. All that man can do is to take advantage of these arrangements, and so manage them that they may work out for him the purposes he desires.

It might perhaps appear that when man exerts his muscular strength, he produces directly a certain effect; but such is not the case. For every exertion used, a certain amount of muscle is destroyed, jus as in the galvanic battery a quantity of zinc is consumed for every manifestation of galvanism; so that in no instance does man of himself originate a force. In every example of power acting, a certain cause is accompanied by a certain effect, each being equal and opposite to the other, and both the consequence of arrangements present in matter.

The muscular effort being sustained by loss of substance of the muscle—or more strictly speaking, by change of structure, for matter or volume cannot be lost however they may be changed or transferred—man himself is a machine just as the steam engine or a clock or any other piece of mechanism is one. But it may be observed in passing, that man as well as all other animals must have been created by some Being infinitely more wise than man himself, for the effects produced by the arrangements in the matter of which they are composed, and which constitute the power of the machine, are *perfectly* obtained, as the following considerations will testify.

Whenever motion is resisted, friction is produced, and a corresponding amount of heat generated; therefore the quantity of heat found in any machine intended solely for force shows an equal amount of loss of the moving power. The heat might be taken as an index of the power lost. For instance, if friction take place between the parts of a moving machine, it consumes a certain quantity of power, and heat is substituted. In proportion then to the heat the machine is imperfect. If in a galvanic machine heat be produced in overcoming resistance, it occurs at the expense of the galvanism. Now, in every machine made by man, heat is always generated to a greater or less extent by friction and other causes, showing defect in the application of the arrangements of matter. But in living machines, no heat is ever produced by the moving power being lost; the heat provided for by the economy of the system, necessary for its existence, is always present, and depends on a definite cause—chemical action; but this has nothing to do with friction, or any other effect produced by the power intended for the manifestation of force. Whenever power in the living machine is intended to be called forth, the whole cause is changed into the desired effect; none is lost in heat or other extraneous developement, 'thereby proving that in this particular instance of work done, the Creator of living beings is infinitely more intelligent than man.'

But to return to our subject—when man by means of steam or any other contrivance seems to call forth power, it must be remembered he does nothing more than to take advantage of the arrangements which have been made. All the intellect on earth could neither make or destroy one particle of matter, or take from or add one fraction to its volume. No ingenuity could command a force not already in existence. All that man can do is to bring together substances, so that the established relations *may* be for a moment disturbed, getting up as it were an oscillation in the great ocean of matter, which, quickly subsiding, leaves everything as it was before.

If then all power be derived from the arrangements of matter, the Arranger is the source and emporium of it all. Just as if a man were to arrange the several parts of a galvanic battery and set it in action, another person could develope heat by joining the poles with a thin wire, or chemical decomposition by dipping them into water, and so on; but the latter only takes advantage of the arrangements which have been made for him—the arranger is he whose knowledge enabled him to bring the power into operation; but if instead of simply putting together the materials, he had impressed on them the necessity to act, and had marked the nature of the performance to be effected, he would then indeed be the author and the finisher of the work.

Whatever then we call this agent or arranger, the fact of his having accomplished the great work of Creation, in such a manner, as fully to provide for all the varied changes that can arise, meeting exigencies by modifications of, without departure from, his general plan, shows the perfection of intelligence. The instance mentioned above, of his work in the living engine being the only thoroughly efficient machine shows his all-wise nature; and the following circumstance will further convince the mind of the capacity of the Author of all things. Power being developed by the preservation of the relation of volume or temperature of material bodies, to produce any force it is necessary to bring together substances in such relation to each other that volume or some equivalent may be transferred. Taking then contraction and expansion as the opposite movements whereby a result is obtained, it will be seen that both these movements equally occur; but although power is in that way developed, none is lost to either body. Both are still fitted for the evolution of force under other circumstances; the body that contracts is fitted to take up volume again, and without such an arrangement none other could give it up, and the body that expands can return the space when needed; so that in fine, the very fact of power being developed creates a source of more, and thus there exists a fund inexhaustible, indestructible and unchanging, as long as the sovereign will which produced it wishes it to remain.

With respect then to the question with which I commenced this chapter—what is the extent of the power of man independently of external assistance? we may conclude that he is powerless, except in taking advantage of existing arrangements, and any force he employs must be at their expense, procured in a defined and ordered way, marked by such regulations as quantity, space and time express. But although everything is prepared for man, and all the power he requires and uses is supplied in the construction of the materials about him, yet circumstances are so ordered that nothing is acquired without labour, no force without exertion, or power without management; and on account of the mathematical precision with which all nature or creation is laid down, the more intimately it is studied, the greater is man's knowledge, and the more extensively he can succeed—the entire provision for his wants, and his entire dependence on this provision, being marvellously coupled with a necessary and constant labour of both mind and body.

CHAPTER V.

In now proceeding to another department of creation, we find that the *organic* world exists by means of some agency differing from any belonging to the arrangements or laws of inorganic matter. For instance, vegetables procure from the air the chief or greater part of the nutriment they require for the building up of their frames; and through the roots, also, some substances are conveyed for the support of the plant; but if we watch the ultimate destination of the materials so taken up, we find they are assimilated and joined together to make up certain structures to form the vegetable, which substances, if left to the usual reactions of matter, would resolve themselves into altogether different compounds.

Animals also live by the assimilation of elements which combine in opposition to the general laws of chemistry. The substances which unite to make up the body of either the vegetable or animal fulfil certain conditions quite at variance with their behaviour to each other when removed from the living frame. Compounds are even found in the organic system which cannot be imitated out of it, although the *elements* are easily procured, and, as far as physical circumstances are concerned, under like conditions. For instance, sugar cannot be made except in the vegetable, or in unhealthy states of the animal frame, although the carbon, hydrogen, and oxygen which compose it are easily obtained. Many other compounds might also be named which are every instant produced in the vegetable and animal body, yet which cannot be artificially generated by man with all the aid of science.

These compounds of which the living body is made up, continue as long as the life of the vegetable or animal lasts; but when life is no longer present these compounds decay, or obeying the usual laws enacted by the arrrangement of matter, they separate into their elemental state, or form other compounds more simple and more fixed.

When life is extinct, the vegetable or animal decomposes; the work of forming extraordinary compounds is no longer carried on, but the elements being given up to their inorganic reactions these compounds are destroyed. Thus we see that the organic world is endowed with some agency or power differing from that produced by physical arrangements; or rather that some disposition is made which cannot be imitated mechanically, which regulates all the movements, and is *an addition* to the usual properties of matter without which life could not be found. This agency is the VITAL POWER, and analogically at least corresponds with, or rather, must have been produced by, that which first formed the mass in the inorganic world. Both must have been something different from any power now in matter, each is the first step in the division of creation to which it belongs, and neither can be conceived or explained. So far the similarity of design extends from the inorganic to the organic world; a partial evidence at all events that the same mind which planned the arrangements of matter formed the living being also; and whether this agency be called the Deity or otherwise, it is something that man can neither imitate or comprehend.

The analogy may, however, be still further carried on. It was shown that to accomplish any change in the inorganic world, advantage must be taken of arrangements previously made in matter, man's work consisting merely of placing together materials which afterwards act on each other, and by virtue of the forces laid up in their construction, bring out the object he desires. To produce heat he brings together carbon and oxygen, and he has no longer a control or knowledge of what occurs except in the result. To obtain any of the other forces connected with matter he can but interfere to the same extent, he can only place substances in such a position as that they can give up their store to him, but further he is powerless; and exactly the same principle is in operation in the organic world. The first start having been taken by the creation of a force altogether foreign and, indeed, opposite to these of inorganic matter, that is, the vital power, the subsequent steps whereby life is kept up are all independent of, and unaided by man. Nothing, in fact, is left for him to do, but, as in the inorganic world, to bring substances into proper relationship with his body, and all the rest is accomplished without his assistance. Once the food is placed in the stomach it leaves his consciousness and control, and the arrangements made in the frame carry out the processes by which life is continued. The food, worked on by the stomach and mixed with secretions from it and other organs, is changed into a substance fitted to be taken up by the system and brought into the blood-vessels to be turned into blood. This blood is carried to the several parts of the body after having imbibed oxygen from the air in the lungs, and in every part deposits its new nutriment, whilst the oxygen carries away the old material. The several secretions for throwing off the old body, and for other purposes, are being constantly formed by organs of whose existence we are not even conscious; and, in fine, all the processes of life are incessantly in operation without a thought being given to them by the individual they serve to keep alive; and all these in direct opposition to what are called the laws of matter. Thus the same general plan is continued from the inorganic to the organic world, and the similarity of acting in each leads us to conclude a similar author for both.

But besides the inorganic world, in which I have to a small extent investigated the molecular constitution of matter, and the organic world whose general working has been found to be fashioned after a similar plan, there is still another world, which, although having no physical conformation, or tangible evidence of its being, is yet revealed to us as one we must certainly enter, and, unlike the present, a world we can never leave. At first sight, it might appear difficult to make any comparison between the arrangements of a physical and spiritual existence: the one the object of sense, the other of faith; yet looking at both from the point we have been viewing the former, that is, endeavouring to comprehend the design intended to be carried out, and the means whereby the object is fulfilled, we may be able to compare the processes employed, and see whether a like mode of acting proclaims a common author.

For argument on this point, we can only appeal to the revealed word of God, it is all we have to guide us with respect to our future state. Still, I do not ask it to be conceded, in the first place, that the Bible is necessarily true, for if that were allowed by all, this little book would be a work of supererogation, as it is only intended to prove the existence of the God the Bible teaches. All I wish, is that if a like mind be shown in the dealings of the physical world as seen in the mechanism of organic and inorganic matter, and in the spiritual world as revealed in the Bible, that this very coincidence should prove the truth of the written word, and allow the concurrence, without any argument in a vicious circle, to proclaim its author. In order, therefore, to find whether any correspondence exist between the visible and invisible world, that is, whether the provisions made in both for the use of man are sufficiently alike to show a similar origin, I will briefly discuss the leading truths of the Bible as far as they relate to the subject I have in hand.

CHAPTER VI.

If there were no life for man after his sojourn on this earth, the object of his existence here would be looked for in vain; and as everything, animate and inanimate, is known to have its uses, if man's life were profitless it would be a principle opposed to all the other works of Creation. If we take a general view of nature, we will see that all things are accomplishing some object, and that everything is employed for the benefit of whatever is higher than itself in the scale of being. The rocks and atmosphere commence the chain; the latter so acts on the former that they become fitted for lodging the lowest living productions, and as these die they prepare the bed they form for higher living things; and so the progression goes on until a soil is made, and more highly organized vegetable and animal forms fit it for the occupation of others higher still, and at last MAN is enabled to inhabit what at first was a barren rock.

But here the chain apparently ends. If all the lower vegetables and animals serve to prepare a proper habitation for those higher in organization than themselves, and afterwards continue to be useful to the races they were the means of introducing, and if all things are subservient to the purposes of man, and, as is evident, only made for his use, what is the object of the existence of man himself? If his life ended in this world, he would have spent his brief time in receiving the benefit of all the other parts of creation, and as he is the highest in organization, he would be the only one who would have contributed nothing to the general good. His life would be, contrary to the universal design, without an object.

This view of man's existence is therefore inadmissable from analogy. He must, like every other living thing, be performing some part connected with a higher being than himself, and as no such purpose is accomplished here, it must be hereafter. We are therefore driven to look to some future state of existence.

Now taking it for granted that such a future does await us, the only part that man can act here with respect to it can evidently be but fitting himself for the life he is to enter on there; his concern with the next world is how he is to exist throughout eternity with the greatest enjoyment to himself, and the largest amount of usefulness to the Being he is supposed created to serve; in other words, he is interested for the welfare of that part of him which must outlive his body, or what is commonly called the salvation of his soul from the pain and disgrace which, we are told, attend a disregard of that Being here for whose glory and service he was created.

This salvation of the soul being the most important of all man's wishes when he is convinced of its existence, the plan to be pursued for its attainment has been most earnestly sought. It might appear at first to these who acknowledge only one source of information on the subject, the revealed word of God, or the Bible, that the proper knowledge might be easily obtained; and, indeed, to a great extent, if not in essentials to exactitude, all persons who take the Bible only for their directory, agree; but from those, others, who admit tradition as authority, widely differ. But although amongst the notions of those who take this Book solely for their guide, a seeming dissimilarity prevails, which however on being closely analysed almost disappears, yet to speak of the doctrines of the Bible, for the purpose of deducing any arguments, would be useless without first defining the meaning intended to be attached.

I will, therefore, in the first place endeavour to state briefly and generally what appears to me to be the great truths it teaches. The Bible tells us of all God's works, and chiefly of those with which man is connected. It shows his wickedness and ruined condition, and declares that having committed sin, God's justice could not be satisfied without the promised punishment of death being exacted, and it tells of the sinless sacrifice of God's son to appease that justice, and the consequent triumph of the Almighty in the salvation of man. The final result of all this is the Glory of God and man's Salvation; and it is chiefly with respect to the manner in which the latter is attained, that opinions and readings of the revealed word differ. These opinions are various, arising, I think, partly from the fact that in our reasonings about the Deity, we measure his nature by our own to a great extent, unintentionally, perhaps, applying to him human feelings, and thus obscuring the proper appreciation of his character. I fear that in many instances this almost unconscious attributing of our own feelings to God prevails, and that it fixes the stamp of our opinions and worship; whereas, we ought to look on God as a Being of a perfect nature, perfectly just, perfectly merciful, perfectly wise infinitely perfect in all His attributes; and in any reasoning on things connected with Him, this character should be remembered and have its proper weight.

Now the Bible tells us that man, when placed in the garden of Eden, was pronounced to be very good, yet he did not resist evil. God did not require him to do anything, He only commanded him not to do a certain thing. He asked but a negative proof of his obedience; and man was found wanting. If then man, when he was very good could not obey in abstaining from evil, can he now that he is "desperately wicked" do any good work, or if so, can any amount of goodness wipe away a sin already committed? If not, what can save him from punishment? Can perfect justice be satisfied at the same time that perfect mercy is exercised? We can only see both accomplished in the Bible plan of salvation.

When sin first appeared, God promised a means of escape for man in the death of Jesus Christ, which is a perfect expiation. But this sacrifice, or atonement, having been provided, justice being satisfied, and mercy being possible, on what condition was pardon offered? It was promised unconditionally. God knew if anything were to be done by man, the covenant would never have been fulfilled. Some sects or religious parties, I am aware, say that the attaining to God's promise depends somewhat on our good works and holiness, and others say it depends upon our faith; but all, I think, agree in ascribing both the works we do and our faith to God, and so differ to a very small extent indeed in their opinions, although for want of sufficiently analysing them, they appear to be quite opposed. But the question still is, are both wrong? does God require anything of us? do the faith and works *follow* and not *precede* salvation?

We cannot easily believe in an unconditional salvation, because, as I remarked, we attribute our own feelings in a great degree to the Deity, and unconsciously argue as if such were really true. We cannot understand unconditional pardon to those who hate us, because it is opposed to our own fallen nature, nor do we yet see clearly why God acts so either; but we have only the Bible to guide us for information on the matter, and however different its ideas may be from our own, we find in it this doctrine of unconditional pardon.

This truth is not forced from an isolated passage; —almost any doctrine could be built up if solitary texts be depended upon,—but the general spirit of the Bible teaches that man cannot earn anything of God but destruction. The only passage in which wages are spoken of in Scripture from God to man, is, "the wages of sin is death;" but when a *gift* is mentioned, we read, "the gift of God is eternal life." Man earns the former, but receives gratuitously the latter.

Jeremiah phophesies (and the prophecy is referred to in the 8th Chapter of Hebrews) after showing that the covenant made with the Israelites was useless because they could not perform their part, that God would no longer require anything of them, but would write his laws in their hearts, and forgive their sins unconditionally. Indeed, it is expressly told us in all parts of Scripture that we are entirely without power to do any good thing for ourselves. For instance, amongst others, in the 2nd Chapter of the Ephesians, where it is shown us it is altogether by grace we are saved, and not by works; and, lest we should take the least merit to ourselves, that any works we do which might be called good are prepared in us by God beforehand.* And in Isaiah xxvi. 12. it is said of God, "Thou hast wrought all our works in us," and in Phil. ii. 13. "For it is God which worketh in you to will and to do;" and Scripture abounds in such passages as, "Ye have not chosen me, but I have chosen you."† "No man can say Jesus is Lord but by the Holy Ghost."‡ "Which were born not of the will of man, nor of the will of the flesh, but of God."§ "Without me ye can do nothing."|| "Except the branch abide in the vine it cannot bring forth fruit." And such quotations might be multiplied, this grace being shown to us "not because we loved him, but because he first loved us."¶

Why this love is bestowed on us we cannot tell, we only know in part. God's motives and purposes are not always shown to us, "those things only which are

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* Ephesians, ii, 10.

† John, xv. 16.

‡ 1 Cor. xii, 3

§ John, i, 13.

|| John, xv, 5.

¶ 1 John, iv, 19.

revealed belong to us and our children, the secret things belong unto the Lord our God."* We do not know, for instance, why God permitted evil either at or after man's fall; but we do know, for it has been revealed to us, that wickedness abounded in the earth so as to cause its destruction. Still God repeated the unconditional promise of pardon and redemption to Abraham. Some hundreds of years afterwards the law was given through Moses to Abraham's descendants, a nation chosen by God from all the nations of the earth; and they were told if they kept this law they should live, if not they should die,† thus leaving it seemingly to themselves to earn life. But no one kept the law, and although this condition was attached to it, God knew that no one would keep it,‡ and Moses knew it;§ therefore, if the unconditional promise of God had not been made, and kept before men by means of types and ceremonies illustrative of Jesus Christ the great sacrifice for sin, no one would have lived.

It would seem that one of God's objects in giving the law, was to convince man he was not able to do any good deed, much less to earn any merit from Him. And as this object was gradually made apparent, the rigour of the law was relaxed. At first God said, "He that sinneth must die, and the penalty be extended to the children."* Then He said "every man should die for his own sins only,"† and then, "I will not take vengeance on man for breaking the law if he repents—he may begin the score again and again and try to keep it."‡ Yet even now man could not earn life. God then said, "I will not ask man to do anything, only to repent and have remission of sins."§ And still it was necessary to go further; after every means and opportunity had been given to man to do something for himself unavailingly, Jesus Christ appearing, announces again the unconditional invitation of God to man to take of the waters of life freely, without money and without price.|| Yet even now no one takes the offer of God. When the marriage feast was made, *all* those invited sent excuses, it was only those who were *compelled* to come in that filled the house.

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* Deut, xxix, 29.

† Deut. xxx, 15—20.

‡ Deut. xxxi, 27.

§ Deut. xxxi, 21.

But was there an utter aversion, or carelessness, or ignorance that God required holiness of man? No—the conscience, if nothing else, proclaimed it; but there seemed, in the great majority of people, to be an ignorance of the *sort* of holiness that was necessary. As God is perfectly holy, nothing less than perfect holiness can satisfy him; and men, as St. Paul says, went about establishing their own

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* Exodus, xx, 5.

† Jer. xxxi, 30.

‡ Deut. xxx.

§ Luke, iii, 3.

|| Mat. xi, 28.

righteousness,* whereas if, as Jesus Christ told them, they first sought the Kingdom of God and *His* righteousness, all these things should have been added to them.†

What then does man towards the salvation of his own soul? Can he do more than take the offered escape by applying Christ's death to himself? No work, good according to man's idea, can take away committed sin. Once the act has been done, God's justice cannot ignore it. This justice must be satisfied before his mercy can be exercised, and no good work, or anything except the sacrifice which God has provided in Christ's death, can do so, for if righteousness could come by the law, Christ were dead in vain.‡ Unless God accepts Christ's death for us, and imputes his holiness to us;—for without holiness no man can see the Lord,§ and there is none that doeth good‖—unless God looks on us in Christ, it is impossible, according to the Bible and reason, we can be saved.

Then if Christ's sinless life and death be the onl escape for man, every man must be of equal value in the sight of God, and if Christ died for *all*, why are not *all* saved. God only knows. God has saved some; for it is only those whom He draws can come to Christ;¶ but why it should be so no man can tell.

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* Rom. x, 3.

† Mat. vi, 33.

‡ Gal. ii, 21.

§ Heb. xii, 14.

‖ Ps. xiv, 1, 2, 3.

¶ John, vi, 44.

Even St. Paul, when pressed to answer the question in his epistle to the Romans, confesses his ignorance on the subject, and merely ascribes it to the will of God.†

Then does God allow man, whom he could save, to perish? "Nay, but oh man who art thou who repliest against thy Maker." Our ignorance of God's mind should accept God's revelation as it is given to us, without questioning his right to act as he pleases. Here again we ascribe our own feelings to God when we find fault with his plans. What can we say as to the ultimate reasons of the Almighty. When Adam fell, might he not have murmured against God for allowing death to come into the world, when he might have prevented it. But Adam would have shown not only his presumption, but his ignorance and incapacity to judge. Everything seemed lost to man for ever, and mercy seemed not to belong to God; but out of all this ruin arose the most magnificent dispensation that imagination can conceive. God's doings might be judged by ignorance, but He only knew his own mind; and the glorious result of man's fall and God's seeming severity ought to make us pause before we question, however clear a case we fancy we have, the righteous acts of the Almighty.

Men often object to the Bible plan of salvation,

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* Rom. ix.

that if we can do nothing for ourselves, it is useless to urge righteousness on any person, "Let us then," say they, "enjoy the world, for we have no power to alter our destiny in the next." But they mistake the whole matter. If a man be led by the spirit, he will only take pleasure in the things of God. Man's enjoyment here depends as much on God as it will hereafter. The worst sinner once touched by God's spirit flies his former greatest pleasures and loathes them. Give him leave to enjoy the world as he was in the habit of doing; he feels disgusted, and only enjoys what before was irksome.

The objection that every man may live as he pleases if salvation be provided for him is no objection at all, for every man *does* live as he likes. The sinner delights in his sin, the saint in the earnest and prospect of his inheritance. The sinner and the worldly man think the saint lives a life of restraint and painful self-denial, and to a certain extent so he does; but as the worldly man delights in what seems toil to enrich himself, and denies himself that he may attain his object, the contemplation of which is his greatest joy; so the saint with a thousand times this delight, as his object is a thousand times more elevated, moved by gratitude to God who *has* saved him, and by the hope of his inheritance, feels intense delight in everything that keeps these before him, counts all his losses gains, and only enjoys what to the world seems a separation from earthly pleasures.

But if man can practically do nothing for himself, why are there so many injunctions in the Bible to resit the evil and choose the good ? why are we commanded to work out our own salvation? There is, I fancy, a great misconception of the precepts laid down in Scripture. I do not think there are any commands given to the general mass of mankind to live righteously.

At the time when God gave his law to man, all the Israelites, not all the world, were called on to keep it, although no man by so doing could save his soul from death.* Still it was God's law to his chosen people, and they were ordered to obey it. The Israelites were separated from the world and were confessedly God's people. The rewards offered for keeping the law were offered to them only.

Well, just in the same way, the precepts given under the present dispensation in the New Testament are addressed only to persons already saved, to God's people. All the Epistles are written to the *saved,* as the opening address of each shows. Wherever an admonition to do any good work is given in the New Testament, it is given to those already saved ;

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* Gal. ii, 16—21.

so that the performance of it could have no weight in attaining to salvation. Even Christ's Sermon on the Mount is addressed to his disciples, to those who were already the "light of the world;" so that no persons except Saints are desired to do good for none other can do it, and even these only, as being looked at in Christ; and therefore any argument drawn from precepts or commands given in Scripture to lead a holy life, thereby to prove we are expected to do something towards our own salvation, is worthless.

God's plan of saving man's soul, I therefore believe, is entirely His own work, and altogether irrespective of man's assistance or compliance. He has provided a remedy for his sin without his help, and applies it without his concurrence; and however strange the plan may appear to some, yet the whole tenor of the Bible declares that it is the plan of God.

It is only necessary for my purpose to show the inability of man to do anything for himself towards his ultimate destination in another world. I will not enter into the consequences of this truth; Divines may endeavour to satisfy men on this point. I will only allude to one topic connected with it, and that is, it is said that this doctrine would tempt all men who think of eternity to become careless of their conduct here, as they could not unsettle God's decree hereafter. Now, as I said a few pages back, the inclination to be careless would not be present if God's Holy Spirit be in us. And, besides, I think that generally this doctrine ought to be the greatest stimulus to a holy life; for a holy life is the index of our acceptance with God; and who that has ever thought of eternity and its accompaniments will not wish for that. If any man suffer from a disease which must be fatal, unless a blue mark, the index of recovery, appears on his hand, will he not look nervously for the appearing of that spot, and be delighted when he sees it. Exactly so, any man that knows what eternity is, will, if he think holiness the privilege of the Saints only, anxiously endeavour, with God's assistance, to secure it; and when he finds it and exercises it, will feel that faith and assurance of his salvation which is the index of his final state.

Before, however, leaving this part of my subject, I must remark that although it seems plain to me that God only is instrumental in the salvation of man, and that nothing depends on man himself; yet that it does not invalidate my argument, even if we admit that man's exertions here on earth have much to do with the state in which he spends his eternity. All shades of opinions agree that God has prepared the necessary remedy for man's sin, and the only way to enter Heaven. Difference of opinion only exists as to the amount of self-emanating righteousness required of man. It matters not how much it may be said he must do; we all agree that God has made the arrangements by which salvation is accomplished, and that it is only by virtue of these arrangements we can ever attain to it, be our responsibilities great or small.

CHAPTER VII.

In order then to draw conclusions from the foregoing views, it is necessary to remember that in the first chapter it was shown that in the physical world arrangements must have been made amongst particles, or that a certain constitution must have been given to matter by some power different from any at present operating on it; and that in order to allow of the action of what are called the laws of matter, a previous disposition into masses must have been procured, just as before galvanism can be evolved, a certain arrangement must have been made in the materials which produce it.

It was also shown that all the "forces" so called, such as Light, Heat, and Electricity are the results of these arrangements, and consequently that the Author of these must have been, and, as long as they last, must continue to be the creator of all power; and that man is unable to do more than take advantage, and that imperfectly, of these arrangements; his inability to create any motion or force declaring him altogether a dependent being, and proving his entire incapacity, so to speak, except so far as his Creator has provided for him. In the fifth Chapter it was shown that as in the inorganic, so in the organic world, the several phenomena which constitute the living machine are the result of some disposition of parts—LIFE—different from any which it is found possible for matter to produce, and which depends on the action of the arrangements made in the vital economy, obviously requiring a wisdom and power so superior to man's, that, so far from imitating, he cannot even comprehend them; and it was likewise demonstrated that in the working out of the processes on which life depends, man is as powerless as in producing anything in the physical world; his part consisting merely in taking advantage of the arrangements which have been made for his benefit. And lastly it was shown that with respect to a future world, a like step impossible for man or matter to accomplish—the death of Christ—was taken, without which starting point no progress could be obtained, as in the inorganic world none could be achieved without the formation of masses, and in the organic world without the creation of life.

As in the physical world the "forces" necessary for the continuance of the present order of things are provided for by a *supernatural* exercise of power, the FORMATION OF MASSES; and, as a consequence of this great first movement, are kept for use in the arrangements which are made in matter; and as in the organic world the peculiar actions require a like supernatural first step to be taken in the creation of the VITAL POWER by virtue of which alone the further processes can be carried on; so in the economy of the world to come, a first supernatural provision has been made in the DEATH OF CHRIST, with which all progress, and every circumstance of man's future state are connected, and on which the power of doing anything equally depends.

Arguing then from these propositions, it must be admitted that a true unity of design, or sameness of action manifested in the several departments of creation, both organic and inorganic, and extended to the unseen world, shows a common author for all, and forms a sort of bridge from the evidences of the senses acted on by external matter, to the faith of the mind in the existence of an immaterial Deity; reminding us that "the invisible things of Him from the creation of the world may be seen, being understood by the things that are made."

This similarity in the mechanism and economy of the present, and preparation for a future world may be still further extended. This seeming paradox applies to each: that although in whatever is essential to his well-being, man is hardly trusted even with taking advantage of the arrangements made for him; and although so little is left to his own exertions or judgment, yet he is obliged to labour as if everything depended on himself. For instance, Heat, which is so needful, is the result of certain changes which take place in matter, and man must bring together the necessary materials in order to produce it. Electricity, likewise, can only be procured by suitably arranging the substances which evolve it. In the same way, in the animal world, food must be sought as it is necessary for the maintainance of the body, and air must be drawn into the lungs to purify the blood. And with respect to Eternity, although, as in the other parts of creation to which I have alluded, everything has been done for us by God, yet we must use the means he has appointed, such as prayer and study of his word, and, in fact, labour as if our salvation depended on ourselves, although we know that it does not.

But in all, the less essential anything is to the well-being of man the more he is trusted to for its accomplishment. For instance, electricity is not so indispensable to man's existence as heat, and therefore it requires more of his own work to procure it. The maintenance of the body by food is necessary, but man can live for many hours or days without it, therefore he is trusted with its preparation to a certain extent, because time lost can be spared; but the drawing in of the air to purify the blood, admitting of no cessation or delay, its importance causes it to be taken nearly altogether out of his hands, and made a condition independent of his labour or his thought. Instances of the same kind might be multiplied, in fact it is the great principle on which created beings are generally regulated; and it extends to the affairs of the soul. The spiritual life of man being of more consequence than any other concern he is connected with, is altogether taken out of his management, and God having made provision for it by the death of Christ, He disposes of it as seems best to himself, and thus carries out in the government of every portion of creation, past, present, and to come, a like arrangement with the same apparent means, or perhaps more properly speaking with the same method of acting.

In conclusion, if we look at the constitution of matter, the impossibility of a mass being formed, even though atoms might have been in existence, without the interference of some agency different from any at present operating; viewing its arrangements, measured out and bounded with mathematical precision, we must admit that some Being greater than any on this earth and more powerful than the supposed laws of matter has formed it. Seeing also that in all departments of creation, the object preeminently provided for is the welfare and preservation of man, and that the same method is everywhere manifested in carrying it out, we must likewise conclude that the same power which made the arrangements in matter is also the author of our being.

As in the animate creation, the organization of every living thing is made from one type, so in creation generally, one plan is taken for the working out of all its details; and whether we examine the combustion of coal, the growth of the living body or the final destination of the soul throughout eternity, we see the same principle followed out in the accomplishment of each, and we are forced to ascribe a common authorship to all. It is abundantly evident that one mind at one time conceived and set in motion the entire fabric of creation, and that everything from the smallest particle of matter to the highest organization and disposition of life and power in every stage of its existence depends for its continuance on Him, and that in everything we do, or think we do, we only use the power he has given; and therefore in all our ways we are indebted to Him, and in all our works, however unconsciously, we worship Him. Whether we pride ourselves on the power of our steam-engines, the rapidity of the telegraph, or the beauty and excellence of photography—the results of Heat, Light and Electricity—we only declare the wonders of the mechanism He has provided, and the perfection of the arrangements He has made. And as by virtue of these arrangements, the coal and air when favourably placed together evolve heat, the zinc and acid electricity, and the sunbeam and sensitive salt the photograph, so does food taken into the body by virtue of the vital power continue life, and enable the animal to move; and so the blood of Christ applied to the soul, makes that also alive and capable of acting.

In every word we speak we praise Him, in everything we do we must acknowledge Him; we trace in all creation the same hand, in all its arrangements the same mind, and therefore in every thing we think or act, to Him be all the Glory.

APPENDIX.

APPENDIX A.

ON THE HEAT OF CHEMICAL COMBINATION.*

In the course of some investigations respecting the cause of the heat of chemical combination, I found that some facts hitherto unnoticed, or not sufficiently attended to, required to be proved.

The first of these propositions is, that *the decomposition of a compound body gives rise to as much cold as the combination of its elements produces heat.*

To me this is a new idea, and one with which I have not met in any work on chemical research. I believe it will be found important, and in the present paper I will confine myself to a proof of its truth.

2. That decomposition generally requires a certain

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* **From the Philosophical Magazine for October, 1851.**

APPENDIX A.

ON THE HEAT OF CHEMICAL [illegible]

In the course of some investigation [illegible] cause of the heat of chemical com[illegible] that some facts hitherto unnoticed [illegible] attended to, required to be [illegible]

The first of these propositions [illegible] *position of a compound* [illegible] *old as the combination* [illegible] *eat.*

To me this is a [illegible] t in a [illegible] be [illegible]

is
for
rain
zinc,
raise
1° F

amount of heat is admitted, for, as a general rule, heat causes decomposition; that is, to decompose a substance, a source for the supply of heat is necessary, or some body, capable of giving up heat to the compound to be decomposed, must be brought into its vicinity before decomposition takes place.

3. That *decomposition* absorbs as much heat as combination produces, might be proved by the fact that in double decompositions no heat is given off. We know, for instance, that carbonic acid and magnesia in combining produce a certain amount of heat, and that sulphuric acid and potash likewise give rise to a definite quantity; and yet, when sulphate of magnesia, and carbonate of potash are mixed in solution, although such combinations take place, no rise of temperature (except that of solidification) occurs. Does not the decomposition neutralize the effect of the combination?

4. In cases of simple decomposition, the same result does not obtain. We know from the researches of Andrews and others, that certain bases produce, on combination with acids, certain amounts of heat, and that each base gives rise to a different quantity. Andrews has also proved that if one base displace another, a definite rise of temperature is the consequence. Now, if the rise of temperature be examined, it will be found that it is ***the difference of amount produced by the combining and separating bodies.*** For instance, an equivalent of potash, by

combining with an acid, produces 6½ units of heat; ammonia, 5½ units. If the potash displace the ammonia from any of its combinations, one unit of heat is the result; the difference between 6½ units of heat produced by the formation of one salt, and 5½ units of cold by the decomposition of the other.

5. It occurred to me, however, that the fact might be proved more satisfactorily by finding what amount of heat is given off by the combustion of zinc, than ascertaining what quantity is evolved by its oxidizement in water; for, as the water must be decomposed, we should have the amount of heat in the second instance less than that in the first, and less by the quantity of heat produced when hydrogen is burnt. And such I find to be precisely the case.

Grassi shows that 1 lb. of oxygen, uniting with hydrogen, raises the temperature of 43.4 lbs. of water, 180° F.

The amount of heat produced, according to Despretz, when zinc is burnt, is sufficient to raise the temperature of 53 lbs. of water 180° F.

I find that 1 grain of zinc by dissolving in dilute sulphuric acid raises the temperature of 60 grains of water 18° F., making the necessary allowance for specific heats, containing vessels, &c.; but 1 grain of zinc is equivalent to 1¼ grains of oxide of zinc, and this would, by its combination with acid, raise the temperature of 60 grains of water 10½° F.

(Graham Andrews). This amount must therefore be taken from the 18° in order to find what is due to the oxidizement of the zinc alone.

One grain of zinc, therefore, by being oxidized, or ¼ of a grain of oxygen uniting with zinc with decomposition of water raises the temperature of 60 grains of water 7½° F.

This is the same as 1 lb. of oxygen uniting with zinc *with* decomposition of water raising the temperature of 10 lbs. of water 180° F.; whereas *without* decomposition, it raises the temperature of 53 lbs. of water 180° F; therefore the decomposition absorbs as much heat as would raise 43 lbs. of water 180° F., the same amount which we saw the combination of oxygen and hydrogen was capable of producing.

6. If zinc be dissolved in *muriatic acid,* I find that 1 grain causes a rise of temperature equal to 21° F. in 60 grains of water; or 1 lb. of chlorine uniting with zinc *with* decomposition of chloride of hydrogen raises the temperature of 6 lbs. of water 180° F. Abria (L'Institut, Vol. XIV, p. 635) found that 1 lb. of chlorine uniting directly with hydrogen would raise the temperature of 36 lbs. of water to 180° F.; that is 8-10ths of what oxygen produces. If chlorine, uniting with zinc, produces likewise 8-10ths of the heat oxygen does under similar circumstances, 42 lbs. of water would be raised 180° F. by 1 lb. uniting with the metal. In other words, zinc uniting with chlorine *with* decomposition of

chloride of hydrogen produced 6 units of heat, *without* decomposition 52 units. The difference, or 36 units, is what the combination of chlorine and hydrogen produce, and consequently what is lost by decomposition.

7. When 1 lb. of zinc is dissolved in nitric acid, it raises the temperature of 43 lbs. of water 180° F., more than twice as much heat as is produced by its solution in sulphuric acid. This combination is accompanied by decomposition of nitric acid.

The last two instances are brought forward for the present only to prove, that it is not because zinc is oxidized under different circumstances, as in air and water, that different amounts of heat are produced, but that an absorption of heat always accompanies decomposition, and varies with the substances decomposed. The first instance, the solution of zinc in sulphuric acid, proves that this absorption is equal to the quantity liberated when the same elements combine.

8. When I had satisfied myself so far, I thought that if a compound body could be decomposed directly, or without combination at the same time taking place, a positive loss of temperature ought to result; and it occurred to me that the decomposition of water by the galvanic battery might be an experimentum Crucis. I forgot, however, the heat that is produced by the resistance offered to the current in passing through the water. Still, on

consideration, I saw that the experiment would prove whether decomposition occasioned loss of heat or not; for, although heat is given out by the resistance, might not the amount of that heat be greater if no decomposition accompanied it? If the idea I adopted were correct, not only should such be the case, but the difference should be the amount of heat the liberated gases would give if again chemically combined. And now the problem was to find whether the heat produced by a galvanic current passing through water was what was due to the resistance offered, or whether decomposition made it less, and how much less?

9. The manner in which I endeavoured to solve this question was, as follows:

Having set a battery, consisting of twelve Daniel's cells, copper cylinders 5 inches high, 3 inches in diameter, with brown paper diaphragms and amalgamated zinc, into action, as one series, I noted to what distance the needle of a tangent galvanometer moved when the current passed through the copper ring, which was 12½ inches in diameter. I then included in the circuit a volta-electrometer holding acidulated water, and again noted to what division of the scale the needle moved, the current having passed through the fluid in the electrometer with the decomposition of the water. The difference of the tangents of the angles, when the electrometer was included and when it was not, showed the resistance the water offered to the current. I now removed the electrometer, and in its place introduced a fine platina wire of such a length as offered the same resistance to the current that the water did, which I knew by the needle of the tangent instrument being equally deflected by both. I had, therefore, two substances offering the same amount of resistance, and consequently developing the same amount of heat; but in one case decomposition was present, in the other it was not; what then was the result? Exactly what I anticipated—*the heat liberated by the passage of the current through the water was less than that produced by its passage through the wire, and to the same amount that the gases given off would develope, if again chemically combined.*

10. I tested the truth of this proposition by many experiments, varied in different ways, both as to quantity and intensity of the current, the amount of resistance and the duration of the experiment, and in every case met with a similar result. The details, therefore, of one or two experiments will suffice.

I filled a glass tube with an ounce of acidulated water (one part by measure of pure sulphuric acid s. g. 1.84 to six parts of water); I put two platina leaves into the fluid, and sending a galvanic current through it by means of the twelve cylinder battery, I decomposed the water—1½ cubic inch of gas was given off in the minute; and the tangent instrument having been included in the circuit, the needle rose to 21 degrees on the scale. The current passed through the water for two minutes, and the temperature rose from 75° to 83° F. I now removed the platina leaves from the fluid, and substituted a platina wire of such a length as kept the needle, the current having passed through the wire, at 21°. The same fluid into which the electrometer leaves had been immersed now surrounded the wire; the current in the former case passing through the water and consequently *with* decomposition, in the latter through the wire without it; and after traversing the wire for the same length of time, the temperature of the fluid was raised from 75° to 90° F., that is 15°, or 7° more than in the case where decomposition accompanied it; although in both cases the same resistance was offered to the current, and of course the same amount of heat generated, therefore the 7° F. were absorbed by the decomposition. In the two minutes that the experiment lasted, 3 cubic inches of gas were given off: Now if these gases were made to combine chemically, what amount of heat would they produce? The same that their separation caused a loss of, viz., about 7° F. to an ounce of water acidulated as above; for 3 cubic inches of the mixed gases in proper proportion to form water weigh ·387 gr.; and as oxygen is 8-9ths of the mixture it must weigh ·344 gr. Now as 1 lb. of oxygen combining with hydrogen would cause the temperature of 43 lbs. of water to rise 180°, 1 grain would raise the temperature of 43 grains 180° F., then ·344 gr. would raise the temperature of 43 grains 62° F., or of 1 oz. very nearly 5°.6 F. But the specific heat of the acidulated water to that of distilled water is as 8.3 to 10; therefore the 5°6 must be raised inversely in that proportion or to 6°7 F. In our experiment very nearly the same amount was lost by their separation.

11. I tried the experiment in another way. Through the bottom of a glass tube, I passed two short pieces of thick platina wire, and attached to each a fine wire which reached to the top of the vessel; I could join the wires at the bottom so as to make the two thin wires into one, or separate them by disuniting the thick pieces outside the bottom of the tube. In the former case, the current passed through the wire, in the latter through the water. Each offered the same degree of opposition to the current. Here the same wires that acted as the leaves of the electrometer conducted the galvanic current; the same fluid was used, and the same vessel; in fact everything was the same, except that in one case decomposition accompanied the resistance, in the other it did not; and in the former the temperature did not rise to the same degree as it did in the latter, and it was as much less as the combination of the gases given off would have produced.

I also placed in the circuit two glass tubes, each containing the same quantity of acidulated water, in one of which were the leaves of the electrometer, in the other a platina wire offering the same resistance as the fluid so that the galvanic current passed through both at the same time, and with the same result as in the other experiments.

12. I might bring forward many such experiments; but although they vary in details, they are all the same in principle, and prove the same fact. Enough, I think, has been said to establish the truth of my proposition. If admitted, some interesting difficulties may be removed by its application; for instance, it explains why some compounds, such as alcohol, turpentine, &c., do not give out as much heat when burnt, as their elements do when separately ignited. It may also be made the means of determining the amount of heat produced by the combination of bodies, as the loss occasioned by their decomposition shows the gain by their combination; and in many other ways the principle may be turned to advantage. For my present purpose, I only ask that the simple fact I have endeavoured to prove be allowed, viz., *that decomposition of a compound body occasions as much cold, as the combination of its elements originally produced heat.*

Absorption of heat by decomposition was first proved by me in the foregoing paper in 1851. Mr.

Joule published in nine months afterwards in the Philosophical Magazine, a paper proving the same fact in the same manner as I did; and notwithstanding this late appearance, he claimed priority of discovery because he had sent to the French Academy a sealed letter which contained it in 1846. The contents of this sealed paper were of course not known to any person, and might have remained so until now only for my publication; and having first made it public, I should no doubt be considered the discoverer.

A discussion on this subject between Mr. Joule and myself will be found in the Philosophical Magazine for 1856. Although Mr. Joule says he discovered this law so long ago as 1841, and published it in the Philosophical Journal for that year, I show, in the discussion alluded to, that he was not aware of it, because he neglects to take it into certain calculations, the results of which should be greatly influenced by so doing. Indeed it is evident he could not have thought he published it in 1841, as he makes it the subject of a sealed letter in 1846; unless he imagined it was kept secret in the pages of the Philosophical Magazine for so long a time.

(T. W. *May*, 1860.)

APPENDIX B.

*On the Existence of Multiple Proportion in the quantities of heat, or equivalent alteration of internal space of bodies, caused by definite changes of state as produced by Chemical Combination or otherwise.**

Gay-Lussac having shown that the combining proportions of gases and vapours are either equal in volume or some multiple of each other, and other chemists, particularly Playfair and Joule, having extended the same law to solids and liquids, it is evident that *specific volume* of its combining equivalent is characteristic of matter. But as every substance is composed of matter and space, or of particles with some distance between them, as is shown by expansion and contraction, whenever volume is altered there must be either an addition to or subtraction from the internal space of the body. This alteration of volume is evident in the case of bodies expanding or contracting by gain or loss of heat; but in chemical combination, where alteration of internal space must take place also (as shown by change of temperature, and because *specific* volume being characteristic of matter, this volume must change when the matter changes, by a substitution of a mixture of two kinds of matter for one), in chemical combination, I say, this alteration of internal space is not so plainly demonstrable. Still, in the change of temperature, we have not only an evidence, but a measure of the change of state of combining bodies. For, the phenomena of heat being produced by a *dual* force acting equally in opposite directions, one body cooling or contracting as another becomes heated or expands, it may be taken for granted that whenever heat or expansion is found in one body, the opposite change is occurring in some other. Now, regarding this proposition as true, it is intended to be proved from the combinations of oxygen that the internal space of a substance is lost and gained in multiple proportion, in the definite changes of state of bodies, such as in the condensation of vapours into liquids, and liquids into solids, and the reverse; and also in chemical combinations and decompositions; and therefore that the *space* as well as the *matter* of which volume is composed can be only added to or taken away in what is called its combining equivalent.

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* From the Proceedings of the Royal Society, January, 1856.

In order to find whether the heat of chemical combination, which is taken as equivalent to the alteration of internal space, is equally produced by the same substance uniting with others, or if not, if it is given out in multiple proportion, oxygen is made to combine with several other simple bodies, and the alteration of temperature noted.

The method of oxidizing these substances, the details of each process being given in the paper, consisted in dissolving them in some suitable menstruum,—for instance, in sulphuric acid, liquor of potass, and nitric acid. When the two former are used, water is decomposed to oxidize the dissolved body; in the last case, the nitric acid is resolved into oxygen and binoxide of nitrogen, the former of which unites with the substance to be oxidized, the latter escaping. Other combinations and decompositions at the same time take place (as detailed in the paper), and being taken into account (decompositions absorbing as much heat as is produced by the combination of the constituents), the alteration of temperature by the oxidation alone is arrived at.

In this manner eighteen different metals were oxidized, but the heat of oxidation was obtained satisfactorily only with twelve. Other experimenters (Favre, and Silbermann, and Andrews) have, with a different object in view, found the heat of oxidation of fourteen other substances; their conclusions are added as being from unprejudiced sources, and the result of all the experiments is brought together in a table, in order to see whether the law of multiple proportion exists. The numbers found by the different experimenters are all calculated to the same standard. The unit of heat is the amount necessary to raise the temperature of 1000 grains of water 1° Fahr., and the quantity of metal oxidized is an equivalent of each, oxygen = 1.

To find whether the law extends to change of state when no chemical combination takes place, the amount of heat given out by the condensation of an equivalent of steam, and by the solidification of an equivalent of water, is given. The following is the table of the thermal equivalents of the several substances, the names of the experimenters, and the ratio of proportion. It is to be remarked, that the condensation of steam being in multiple proportion with the other thermal equivalents, the expansion of all other bodies into vapour must be included; for I showed in the Philosophical Magazine for January 1852 (page 48), that all bodies expand into vapour in some multiple of their atomic volumes, and their atomic volumes being in ratio also, their expansion or gain of internal space in this definite change must be in multiple proportion.

Table showing the quantity of heat produced in 1000 grs. of water by the oxidation of an equivalent of each substance, O=1.

Name of substance oxidised.	Units of heat.	Ratio.	Name of Experimenter.
Latent heat of ice	·1603	·1603	
Latent heat of steam	1·287	8 times ·1603	
Iodine	·8	5 times ·1603	Woods.
Chlorine	—1·6	......	Favre and Silbermann.
Nitrogen	1·6	twice ·8	Woods.
Silver	1·6	......	Woods.
Selenium	2·7	......	Favre and Silbermann.
Mercury	2·4	3 times ·8	Woods.
Palladium	2·42	......	Woods.
Molybdenum	8·38	4 times ·8	Woods.
Carbon	3·3		Favre and Silbermann.
Arsenic	4·8	......	Favre and Silbermann.
Antimony	4.8	......	Woods.
Copper	4·9	6 times ·8	Favre and Silbermann.
Cobalt	4·8	......	Woods.
Bismuth	4·82	......	Woods.
Nickel	6·5	8 times ·8	Woods.
Lead	6·2		Favre and Silbermann.
Hydrogen	7·8	......	Favre and Silbermann.
Tin	8·0	......	Mean of Andrews and Favre and Silbermann.
Phosphorus	8·1	10 times ·8	Favre and Silbermann.
Cadmium	8·18	......	Woods.
Iron	7·95	......	Mean of Andrews and Favre and Silbermann.
Zinc	9·6	12 times ·8	Favre and Silbermann.
Manganese	10·4	13 times ·8	Woods.
Barium	12·8	16 times ·8	Woods.
Aluminium	16·16	20 times ·8	Woods.
Sodium	17·5	22 times ·8	Favre and Silbermann.
Potassium	17·3		Favre and Silbermann.

Note.—I proved in a paper published in the Philosophical Magazine for October 1851, that "the decomposition of a compound body absorbs as much heat as the combination of the elements originally produced." I believe I was the first to prove this as a general proposition, and, by so doing, laid the oundation of all the thermo-chemical researches since carried on; for, as far as I am aware, no process which took decomposition into account was used before my paper was published.

In a paper read to the British Association at Belfast, and published in the Philosophical Magazine for November 1852, I proved that the intensity of chemical affinity might be measured by the quantity of heat produced by the combination.

As regards the first of these papers, Mr. Joule published in the Philosophical Magazine for June 1852, a memoir proving exactly the same proposition, but giving me the merit of priority in a preliminary remark. It is, however, singular that Favre and Silbermann bring forward in 1853 (Annales de Chimie et Physique, vol. xxxvii. p. 507) the very same experiments to prove the same fact, and give it as their own.

As regards the second paper. In six months after its publication, Messrs. Favre and Silbermann (Annales de Chimie et Physique, vol. xxxvii. p. 484) prove the same truth with the same experiments, using exactly the same metals, and give their memoir as producing an original idea.

I notice these coincidences here as being remarkable, and because the propositions contained in the paper referred to are the ground-work of the present experiments, and also with a view to prevent an unconscious repetition on the part of Messrs. Favre and Silbermann.

APPENDIX C.

On the Time required by Compounds for Decomposition.[*]

The difference between quantity and intensity of a galvanic current has been long recognized. The former is generally taken to mean the effects produced by the current where no obstacle, or the least possible, exists; the latter the electromotive force, or its power of overcoming resistance. In order to come as near as possible to the cause of different degrees of intensity in different galvanic arrangements, let us analyse and compare any two; for instance, the usual voltaic pair of two metals and one fluid, zinc and copper in dilute sulphuric acid, and a Grove's pair, consisting of two metals and two fluids, viz. zinc acted on by sulphuric acid, nitric acid being decomposed in contact with platina. The electromotive force of the latter is much stronger than that of the former; yet the only difference in the chemical actions taking place is, that at the platina end of the Grove's *nitric acid* is decomposed, whilst *water* is decomposed in the other. Now except for this difference, all things in the two arrangements being the same, if we measure the amount of electricity passing from one end to another of each circuit by means of a galvanometer, we shall find that the quantity as well as the intensity of the Grove's pair is greater than that of the other; the needle of the galvanometer will stand at three or four times as many degrees with the current of the former as with that of the latter. But, as might be expected, if we weigh the zinc both before and after the current has been passing for the same period of time in each, we shall find that in the Grove's three or four times as much zinc has been dissolved as in the other. What, then, is the fact?—that in the Grove's pair, the electricity passes with three or four times the *rapidity* it does in the pair with one fluid; and the only difference between the pairs being, that in the latter water is decomposed, and in the former nitric acid, it follows that *an equivalent of nitric acid decomposes three or four times more quickly than one of water under like circumstances.*

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[*] **Read at the Meeting of the British Association in Dublin, August 26, 1857. Phil. Mag. vol. xiv. Nov. 1857.**

To proceed more exactly. I put a porous vessel into a gutta-percha trough, and filled the latter with sulphuric acid, sp. gr. 1·1. In the sulphuric acid I placed an amalgamated zinc plate, and in the porous cell a platina plate surrounded by several solutions in succession, such as nitric acid, solution of sulphate of copper, solution of nitrate of silver, &c. These solutions in the porous cell suffered decomposition when the zinc and platina plates were joined externally, the base being thrown down on the platina plate. There was therefore no polarization; and I introduced a sufficient resistance externally to render the resistances of the solutions which were decomposed, comparatively nothing. I had therefore several combinations similar in every way, except in the fluid that surrounded the negative or platina plate; and the only difference in the chemical actions of the pairs was in the *decompositions* which occurred. If, therefore, on transmitting the current produced by joining the metals through a galvanometer, there was any difference in the amount of electricity, this difference must have been occasioned by the decomposition alone.

Sulphuric acid surrounding the porous cell, and amalgamated zinc in the acid, I put the platina plate into it and filled it with nitric acid, thus forming a Grove's pair. When the metals were joined, a certain resistance and galvanometer being included in the circuit, the needle of the galvanometer stood at 10¾ degrees of the scale.

I now removed the nitric acid and substituted solution of sulphate of copper, thus forming a Daniell's pair: with the same resistance and arrangement as in the former experiment, the needle stood at 5⅛ degrees.

With solution of nitrate of silver in place of the sulphate of copper the needle stood at 9.

With solution of iodic acid, the needle stood at 10; with acidulated water, at 3⅙.

Now each of these numbers represents the quantity of electricity passing in a given time, or its *rapidity;* and as the pairs only differ from each other in the decomposition cell, it follows *that an equivalent of each compound is decomposed in a different period of time.* The numbers likewise represent the electromotive force of the pairs; *this force is therefore synonymous with rapidity of current.* They also represent the difference between the heat generated at the positive end of the battery by the formation of sulphate of zinc, and that absorbed at the negative end by the decomposition. The latter statement may be proved by subtracting the amount of heat absorbed by decomposition in each particular case from that generated at the positive end. Regnault has proved it in a paper, published, I think, in the August number of the French 'Annals of Chemistry' for 1855; a paper I unfortunately did not see until I had made many experiments myself for the same purpose.

In all these pairs, the same quantity of electricity is developed by the consumption of an equivalent of zinc, but the *time* it requires to make the circuit depends on the time the compound at the negative end takes to be decomposed; and this amount of time depends, again, on the quantity of heat which such decomposition absorbs. Now this proposition leads us to the interesting fact, that all compounds require the same time to absorb the same quantity of heat in decomposing into their elements. For instance, the decomposition of water absorbs 80* units of heat, that of nitric acid 16*, that of sulphate of copper 62*, of nitrate of silver 30*, &c.; and the time they require to do so is exactly proportional to these amounts.

I may here observe, parenthetically, that from the above we can understand the difference of facility with which compounds can be decomposed. All compounds absorbing much heat in decomposing, such as the alkalies, &c., require a comparatively long time to separate into their elements; whilst those which absorb very little heat, decompose at once, and from the most trifling causes; for instance, all explosive compounds, such as the fulminates, hypochlorous acid, &c.: these, not requiring time to absorb heat when decomposing, allow the affinities which form the elements into new compounds to satisfy themselves most easily and rapidly.

But the *time* required by compound bodies to absorb heat in their decomposition is only equal under similar circumstances; for instance, when zinc is the positive pole of a galvanic couple, an equivalent of all compounds at the negative decomposes with a rapidity proportional to the quantity of heat they absorb. Thus nitric acid, which absorbs only about one-third of the heat that water does, decomposes three times as quickly, and hence an equivalent of zinc is dissolved in one-third of the time in a Grove's pair that it is in a Daniell's pair; and an equivalent of electricity passes with proportionate quickness. But if potassium be made the positive metal in one of the pairs, the rapidity of current increases in proportion to the increased affinity of that metal for oxygen. For it seems a curious fact, that some elements, when combining, evolve heat more or less quickly than others; but in separating, the heat necessary for decomposition is absorbed equally; and the greater the quantity of heat an element generates in combining, the more rapidly it evolves it. Hence, as was mentioned before, the rapidity of the electric current depends on the difference of amount of heat evolved at one end and absorbed at the other of the circuit. If a very rapid current is required, a metal which produces the greatest amount of heat is made the positive pole, and a liquid which absorbs the least quantity of heat is placed round the negative one; both ends thus entering into the development of the current.

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* Proceedings of the Royal Society, January 1856.

Faraday says that the current always sets out from the metal most acted on; but this does not always hold good. It is quite possible to have a metal easily acted on by an electrolyte which is a good conductor, and also to have a good negative pole, and yet no current of electricity, because the *decomposition* may not be such as to allow the current to pass. For instance, copper placed in nitric acid in a porous cell, and platina in sulphuric acid around it, gives no current of electricity, although the copper is quickly acted on, because the *decomposition* of the water at the negative end requires more *time* for its accomplishment than the combination at the positive end. If the position of the metals be reversed, a strong current passes. If nitric and sulphuric acid be separated by a porous diaphragm, and a plate of copper be placed in each, the copper in the sulphuric acid acts as the positive metal, although sulphuric acid attacks the metal much less strongly than the nitric acid. Whenever, therefore, we calculate the galvanic effect of a pair, one end of the circuit is of just as much consequence as the other, whether we regard the amount or direction. The electricity is developed at the positive end, but it must pass through the negative end; and on the latter depends not only the rapidity with which it does so, but on it depends also whether it passes at all or not; as, if a fluid is used which takes more *time* to be decomposed than the elements at the positive end require to combine, no current can be produced.

One of the objects of this paper is to direct the attention of scientific men to the importance of the study of the heat of chemical combinations. If the heat produced by the combinations of all the elements were known, we should have a key to almost all the phenomena connected with the principles of chemistry. The reactions of bodies depend on, or are inseparably connected with, the amount of heat their combinations produce: in every instance the result of contact of bodies with respect to affinity could be predicted if the heat of combination of the elements were known; for, *cæteris paribus,* the bodies which produce most heat in chemically uniting always combine to the exclusion of others. This is, however, only a repetition of the truth proved by the experiments of Mr. Joule and myself, that the heat of combination is in proportion to the affinity of the combining bodies. If, therefore, I say, experiments were instituted to find the amount of heat evolved by the combination of the elements, the results would enable us in a great degree to calculate *à priori* chemical phenomena.

The method which I have described for finding the heat absorbed when a fluid is decomposed, viz. by making it the electrolyte in contact with the negative plate of a pair, and taking the needle of the galvanometer as the index of the current passing, and consequently of its rapidity, and therefore of the heat absorbed (as one depends on the other), offers, I think, great facility for experimenting on this subject; the galvanometer here acts the part of a thermometer of chemical action, the needle varying with the amount of heat absorbed by the decomposition, just as the mercury does in the common thermometer for changes of temperature. I endeavoured last year to find the amount of heat produced by the chemical combination of oxygen with several elements; an abstract of the experiments is published in the Proceedings of the Royal Society for January, 1856. The results of the experiments show, that when oxygen combines with several bodies, the quantity of heat produced is not in each instance the same, but is given out in multiple proportion. If the heat of combination be known, we can also precalculate with precision the quantity and intensity of any proposed galvanic arrangement. We have only to find the difference of the amount of heat generated at the positive end by the combination, and that absorbed at the negative end by decomposition. I would just mention, that in this way I prejudged that solution of iodic acid used instead of nitric acid, would give the same quantity and intensity as the latter, when substituted for it in a Grove's pair; and I found by experiment that the idea was correct. The decomposition of iodic acid does not absorb more heat than that of nitric acid, and therefore allows the current to pass with equal rapidity; consequently the electromotive force is the same. However, as iodine is thrown down, this accumulates on the platina, and the conducting power of the plate is interfered with.

Still, as a proof of the value of a knowledge of the heat evolved by chemical combinations in precalculating the result of galvanic arrangements, the experiment was successful.

In conclusion, I would beg to remark that the subject of this paper, viz. the *time* that compounds take to decompose, has not to my knowledge before been taken notice of; and I think it may not be unimportant, if only proving the *definite* nature of another principle connected with the constitution of matter. We know that all the "*forces*," such as electricity, heat, &c., are *definitely*, and after an invariable manner produced by the changes of matter. I have here endeavoured to show that the *time* in which these changes are brought about is also *definite*, and invariably and similarly related under similar circumstances. In "*Mechanics*," without taking into account the *time* in which work is done, no estimate can be formed of the moving power. If we are able to add to the result of chemical action the *time* in which it is performed, do we not advance a step in our investigations, and assimilate chemical to mechanical work more closely?

I would only further ask,—If the equivalents of all the elements produce the same quantity of electricity, as Faraday has shown, and very different amounts of heat, can heat and electricity be modifications of the same agency? For instance, an equivalent of zinc by its oxidizement always evolves an invariable amount of heat and an invariable amount of electricity; an equivalent of copper acts similarly; but whilst the amount of electricity is the same as that from zinc, the quantity of heat is only half as much. All other elements, by combining with oxygen, likewise develope various amounts of heat, but the same quantity of electricity. Can therefore these two imponderables be either modifications of the same force, or be related as cause and effect?

The propositions, then, I have endeavoured to prove in this paper are,—

That electromotive force is the same as rapidity of current;—that with the same positive pole the rapidity is determined by the amount of heat absorbed at the negative end by decomposition, as the more heat is absorbed the longer it requires for absorption.

And that every compound requires a definite and specific period of time for decomposition.

APPENDIX D.

*On the Probable Nature of the Sun's Body.**

The physical nature of the sun's body, whether it be solid, gaseous, or both, is a matter of doubt to philosophers. The peculiar appearance of the spots and the changes they undergo, lead to the supposition that a gaseous envelope surrounds whatever may be the interior; and Arago's determination, that the sun's direct light is not polarized, renders it probable that the envelope is flame.

I have lately made some photographic experiments, which may tend further to the establishment of this opinion. It has been long known that the light proceeding from the centre of the sun is more intense than that from the edge. I have taken several pictures of the sun in a camera obscura, by means of a photographic process, exposing the prepared surface of the plate to be acted on for different periods of time. For instance, the camera being set, and the prepared plate in focus, I have allowed the picture of the sun to fall on it for as short a time as it was possible to uncover and cover again the aperture. I then opened the aperture again for a somewhat longer period, having first moved the plate so that another part of it would be acted on. I caused the picture then to fall on another portion of the plate for a longer time, and so on, taking on the same prepared surface six or eight pictures, each the result of a different length of exposure. The examination of these pictures showed that they were of different *sizes,* the smallest being produced by the shortest exposure; and that they increased in extent with the length of time the aperture was open up to a certain size. The centre of the picture was apparently intensely acted on, as it had the appearance of being what photographers called "burnt." And this deep spot was surrounded by a ring of light not so darkly marked. The "burnt" centre increased in size, not in depth of intensity, with increased length of exposure; the ring about it also increased, but not in proportion to the enlargement of the centre. A piece of red glass placed above the aperture of the camera renders the sun's action less powerful, and allows the pictures to be taken less rapidly. These experiments are a further proof that the light from the centre of the sun acts more energetically than that from the edges; the latter requiring a longer time to produce as much effect as the former on a photographic surface.

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* From the Philosophical Magazine for July 1854.

I thought that these experiments might furnish a ground for obtaining evidence of the probable nature of the sun's envelope. I determined to try whether *flame* would affect a sensitive plate after a manner similar to the sun; and if so, whether a *solid* body producing light would differ in its action. I therefore exposed a prepared surface in a camera in the focus of a lighted candle, and also of a gas-jet. In both cases the action was exactly similar to that of the sun, but more marked, as to variety of extent, in the size of pictures produced, because the light was not so powerful, thereby allowing more leisure in the manipulation. The picture of the flames in one second made a slight impression, in two seconds the impression increased in size and apparent depth of action, and so on, up to 15 seconds, when the picture produced was about three times the size of that taken in one second in the case of the gas-jet. In numerous experiments I have made with flames, caused to burn steadily lest the wavering might influence the result, I have always found that their action on the plate was similar to that of the rays from the sun's disc, viz. an increased extent of picture for an increased period of exposure.

It now remained to try what effect a solid body giving out light—not reflecting it—would produce. It was not easy to find a means of heating a solid body sufficiently high to get a light capable of acting on a sensitive plate. I tried iron heated to whiteness, and platina in the flame of a gas-jet, but neither affected the plate in a camera. The lime-light, however, acted well. A piece of lime acted on by the oxy-hydrogen blowpipe was rendered luminous, and a picture of it thrown on the prepared surface by the camera. In one second a deeply-marked image was produced; and the *size* of the picture of the solid was not influenced by the length of time of exposure. I at first thought a very slight difference of size was apparent in pictures produced by largely different lengths of time the plate was acted on, but I found on examination that the appearance was produced by the gases employed to heat the lime. I mention the circumstance in order to guard others from the mistake.

Taking into consideration all the experiments I have made, I have no doubt that the light from the centre of *flame* acts more energetically than that from the edge on a surface capable of receiving its impression; and that light from a luminous solid body acts equally powerfully from its centre or its edges; and therefore conclude that, as the sun affects a sensitive plate similarly with flame, it is probable its light-producing portion is of a similar nature.

THE END.

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